MANAGEMENT IMPROVEMENT OF

FEDERAL SCIENTIFIC INFORMATION

By

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PREFACE

Early in 1958 the writer was contemplating his future career after completing over three years as a Coast Guard Officer. The choices were between continuance on active duty in the Coast Guard and study in preparation for a career in chemistry and scientific research. Although the years have proven that the first choice was the better, interest in science has been maintained. When given the opportunity to prepare this paper on some area of management, it was natural to integrate an interest in science with an important phase of management--the management of science information and the communication of the results of scientific discovery. Early readings on the subject quickly revealed a controversy which has seriously stifled the improvement of science information at a critical time. The Post World War II period actually marked the beginning of the science information crisis, which is an outgrowth of the unprecedented rise in expenditures for research and development during and since the war.

In recent years steps taken to solve the communication problem have been largely evolutionary, trial-and-error, and generally, unsatisfactory. This paper is concerned with devising a plan to improve scientific communication. Specifically, the question has been asked: Would centralization result in better

management of the Federal Government's scientific and technological information activities? In developing this central question several subsidiary questions become evident: Is centralization possible or feasible? What is the Federal Government doing today in assessing and meeting the problem? What are the organizational, budgetary--the management--aspects which must be considered?

The writer has gained more from the preparation of this paper, perhaps, than will any reader. The task of reading and studying various documentary material, organizing chapters, and finally, writing the paper seems insurmountable at the beginning, impossible at various stages, and manageable only at the very end.

During all stages of preparation the writer has had the invaluable assistance of many. My sincere thanks go to each of them, and especially, to the Senate and House Committee staff members, who provided many leads and access to a great number of publications; the staffs at the Bureau of the Budget and Army Pentagon Libraries; Drs. Karl E. Stromsem and James G. Brown, who provided the essential encouragement and criticism; and my wife, Elizabeth, who suffered through the many drafts, frustrations, and long hours which went into this final product.

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INTRODUCTION

> . . . sciences and the discoveries of science spread and fly aboard at an instant; the communication of knowledge being like that of one candle with another, which lights up at once.
>
> Sir Francis Bacon[1]

This thesis is concerned with communication--with scientific communication--and particularly, how it is managed and operated in the Federal Government, how it is being improved, and how it might be improved even more. The subject and the problem of scientific communication have been consistent with the growth of science itself. Just as Sir Francis Bacon was concerned with the communication of scientific knowledge in the early Seventeenth Century, the problems of increasing complexity in an age of science make it the subject of even greater concern today.

As its main goal this thesis will trace the progress that has been made in the organization and management of scientific and technical information by the Federal Government. The trends which have been developing in the past few years concerning the improvements which might accrue both to administrators in and out of the government and to the ultimate user--the individual scientist and engineer--will also be studied.

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[1] "Sphinx; or Science," Ch. 28 of Wisdom of the Ancients (1609). From: Selected Writings of Francis Bacon (New York: The Modern Library, 1955), pp. 418-19.

The Systems Approach

At the root of all scientific inquiry there is a process of critical examination of facts, step-by-step discovery, tentative theory and decision-making, and development of conclusions based on fact and observation. The process is commonly called the "Scientific Method."

In the recent past, management has developed a scientific method of its own. This method is known by a variety of titles, one of which is called "Systems Analysis." Within the framework of a systems analysis, the following pages will develop the management of scientific information in the Federal Government.

The admission of the existence of a problem is but the first step in the long process of bringing about a change. Several ways of describing the process are available as illustrations.

The Univac Division of Sperry Rand Corporation has a four-step approach to a total system concept: problem analysis, system requirements, design and development, and implementation and operation.

Armond L. Mettler, in Systems and Procedures, treats the change process as a "System Study" with the following parts:

1. Project assignment, with background, suggestions, and project methods, scope, objectives and desired results specified by management.
2. Planning the study.
3. Making a preliminary study.
4. Redefining the problem and adjusting the study.
5. Fact gathering.
6. Recording facts.
7. Analyzing the facts.
8. Developing the solution.

9. Relating the solution to the objectives.
10. Considering equipment.
11. Considering effect of solution on policies.
12. Evaluating the solution against present methods.
13. Preparing the report.
14. Putting recommendations into effect.
15. Follow-up after system is in operation.[1]

These methods have in common the requirement of early recognition of the situation which appears in need of improvement. Each recognize the progressive approach of developing broad concepts and solutions first, and then refining these into more and more detail.

Initial Considerations

What is needed at the beginning of the planning stage? First, an organization must be formed. The President would normally appoint a task force composed of a group representing a spectrum of disciplines. The group has an objective to accomplish and must next arrive at a strategy which would develop the courses of action to be taken.

The task force must have a mandate, an idea of what the Chief Executive desires. Numerous studies have been made by both the legislative and executive branches and will be referred to in later chapters.

However, before turning to the details of proposed changes in existing systems an understanding of the existing system is necessary. To be sure, there is no general consensus for a vast change in scientific and technical information

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[1] Systems and Procedures, ed. Victor Lazzaro (Englewood Cliffs, N.J.: Prentice Hall, Inc., 1959), pp. 33-62.

administration in this country. But many are displeased with the present system and others have advocated a more centralized method of correcting existing deficiencies. Over the past five years considerable change has taken place. The Federal Government has become more interested in the problem but has made what many believe to be stopgap methods of solving them. Therefore, the systems approach being used is an attempt to bring together the major factors which have come to the attention of the Federal Government as a first step in bringing about change.

The paper is divided into four main sections. The first section, Chapter I, develops the information problem as a function of the great rise in research and development during the past two decades. The forces which have caused the information explosion are examined and placed in the perpective of a system in need of some change. The viewpoint taken here, and throughout the paper, is for management to correct a problem which has not always been considered a management responsibility. Management, for the purposes of this study, is considered to be administrators in the Executive Branch of the Federal Government.

Chapter II takes a detailed look at the services which are, or should be, available to a specialized science information center. The development of controls and legislation are covered and several of the major science information activities of the Federal Government are examined for past, present, and future managerial trends.

Chapter III introduces the various measures which have been proposed to improve the management of information systems.

Each recommendation is given a critical examination. General and detailed plans of action are presented with reasons in favor and against each.

Finally, in Chapter IV, four important operational considerations are studied--the user, personnel, mechanization, and costs--in order to provide a reference to the systems method.

Detailed plans, of course, cannot be completely developed in this paper. The future will require well-developed and realistic plans and not the dreams of an informational utopia of push-buttons and instant wisdom. The National Archives Building bears an inscription taken from Shakespeare's "The Tempest": What is Past, is Prologue. If the past is any indication, the scientific developments of the future will exceed our imagination and will demand that we arrange our management of science and scientific communication to better prepare for it.

CHAPTER I

THE NATURE OF THE INFORMATION PROBLEM

The Problem

In 1963, the late President Kennedy wrote:

> One of the major opportunities for enhancing the effectiveness of our national scientific and technical effort and the efficiency of Government management of research and development lies in the improvement of our ability to communicate information about current research efforts and the results of past efforts.[1]

The "information problem" is nothing new. In 1945, Dr. Vannevar Bush, wartime science advisor to President Roosevelt, wrote:

> There is a growing mountain of research. But there is increased evidence that we are being bogged down today as specialization extends. The investigator is staggered by the findings and conclusions of thousands of other workers--many of which he cannot find time to grasp, much less remember, as they appear. Yet specialization becomes increasingly necessary for progress, and the effort to bridge between disciplines is correspondingly superficial.[2]

The growth of science and technology is, of course, only part of the larger growth in all branches of knowledge throughout the world. Science has largely left the matter of information to

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[1] U.S., The President's Science Advisory Committee, Science Government, and Information, A Report, January 10, 1963, p. iii.

[2] Endless Horizons (Washington: Public Affairs Press, 1946), p. 17. Originally published under the title "As We May Think," in the July 1945 issue of Atlantic Monthly.

the working scientists; each scientist working in his area of concern made his personal contacts or kept reasonably informed by review of journals and books which were brought to his attention. Unfortunately, Science and the scientists digest only a fraction of research efforts today. Over one-half million scientists now engage in research and publish the results of their research in a variety of magazines, anthologies, reports and books. It has been reliably estimated that more than fifty per cent of the scientists who ever lived are alive today.[1]

David C. Weeks[2] has pointed out that the volume of publication is only one "obstacle to thorough research; access is still another." He suggested that publication can be compared to the fabled African reptile--the basilisk--whose look was fatal to all who looked upon it. The sheer accumulation of published scientific discovery certainly does not automatically lead to new discovery. However, enough examples of buried discoveries and rejected conclusions exist today because of the inability of

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[1] J. H. Heald, "ASTIA and the Information Revolution," Special Libraries, LIV, No. 1 (January 1963), p. 40, quoting Dr. Burton W. Adkinson of the National Science Foundation. Dr. Derek J. de Solla Price, in Little Science, Big Science (New York: Columbia University Press, 1963), p. 11, has put the figure at the vicinity of eighty-seven per cent. Dr. Price, an eminent science historian at Yale University, arrived at this startling figure by first estimating that the total number of scientists doubles every fifteen years. Figuring the average science career at forty-five years he reasons that there will be three doublings before the present crop of scientists have ceased to be active. This works out to seven scientists working at any one time for every eight who ever lived, or eighty-eight per cent. This says nothing about the quality of the scientists, but the sheer force of statistics assures that a certain constant percentage will be of top quality.

[2] Information Handling: First Principles, ed. Paul W. Howerton (Washington: Spartan Books, 1963), pp. 5-6.

scientists and engineers to rediscover an established finding of the past.

Research and Development Expenditures

In an article in the New York Times, Lawrence Galton observed the immense cost of research and development.[1]

> In its first 150 years as a nation, the United States--Government and industry combined--spent some $18 billion for R. & D. That total was matched in the 5-year period, 1950-55, and almost matched again in the single fiscal year of 1962.
>
> As late as 1940, Government R. & D. funds amounted only to $75 million annually; in 1962 they accounted for 75 percent of total R. & D. expenditures of $15 billion, or well over $11 billion. For fiscal 1964, the budget calls for an investment of almost $3 billion more (close to $15 billion by Government alone), with $7.6 billion earmarked for the Department of Defense, $4.2 billion for the National Aeronautics and Space Administration, $1.5 billion for the Atomic Energy Commission, and the remainder for other agencies.[2]

Research and development has indeed grown almost geometrically in the years since the thirties. The accompanying illustrations, figures 1 and 2, show the rising trends in the Federal Government's involvement in research and development until fiscal year 1964 when expenditures reached almost $15 billion. While the Federal budget has increased by a factor of ten since 1940, research and development has grown by a factor of two hundred times. (If 1940 is not a representative base year, the tables show a five-fold increase since 1952, a trebling since

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[1]Abbreviations for the term research and development (R. & D. and r. & d.) which are contained in a few direct quotations in this paper are left in their original form.

[2]"Will Space Research Pay Off on Earth," New York Times Magazine, May 26, 1963, p. 29.

Figure 1.--Trends in Federal Funds for Research and Development and R&D plant[a]

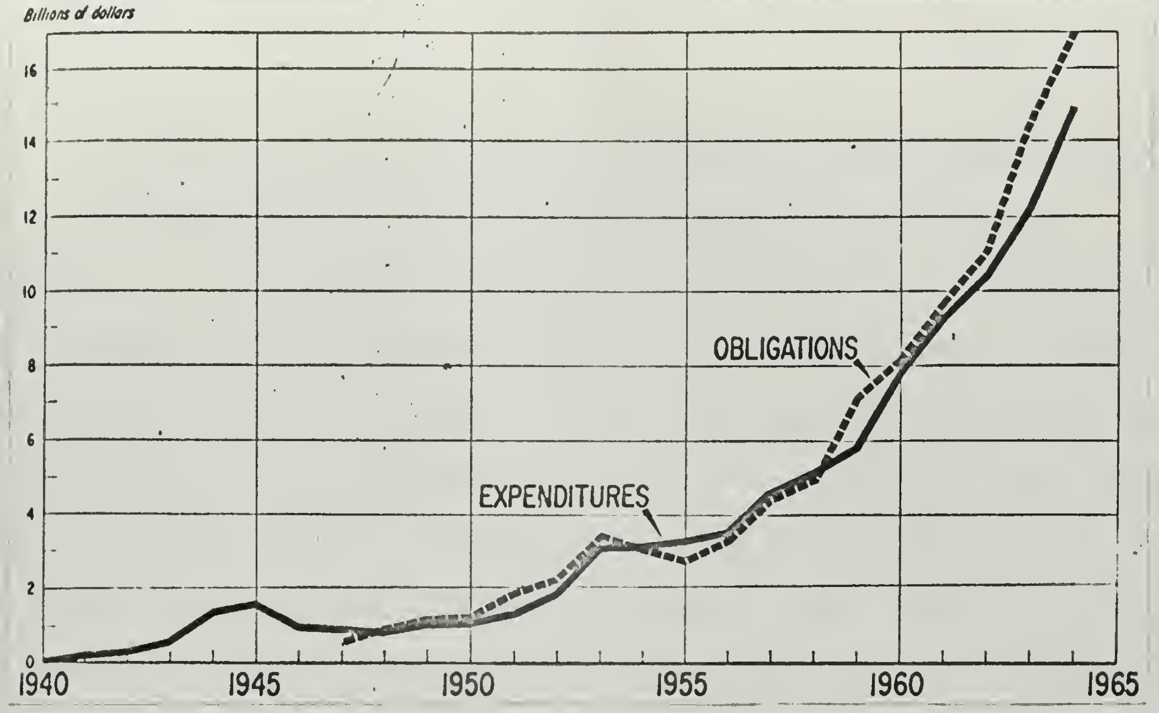
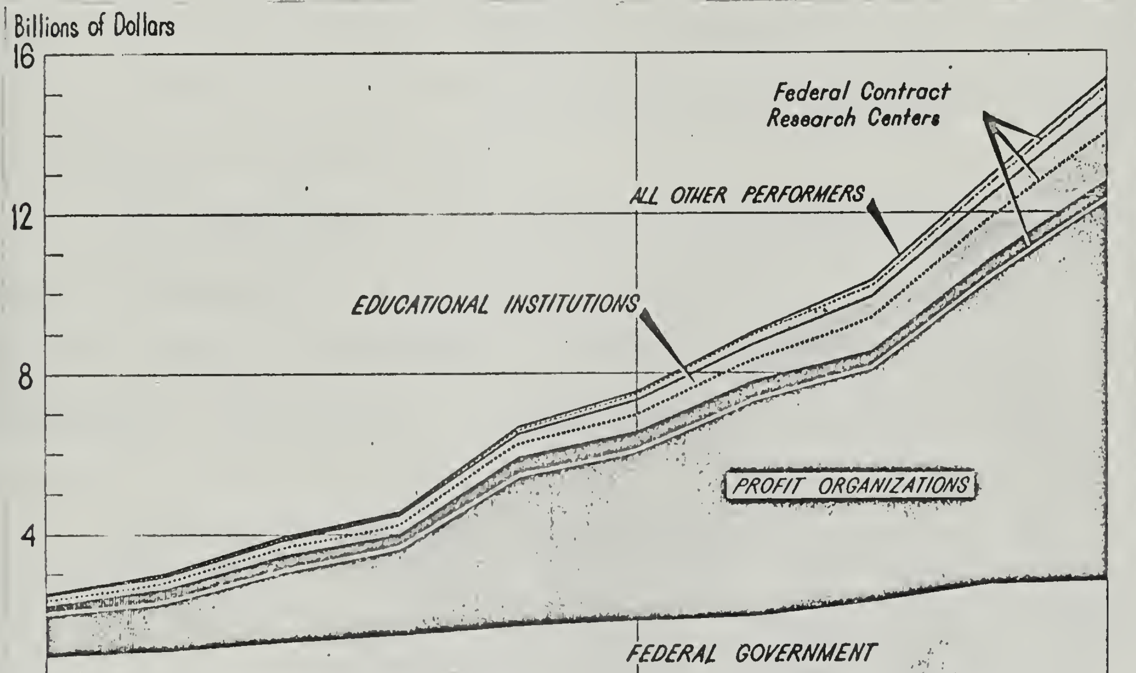


Figure 2.--Trends in Federal Obligations for Performance of Research and Development, by Sector[a]



[a]Source: National Science Foundation, Federal Funds for Research, Development, and Other Scientific Activities, Vol. XII, Surveys of Science Resources Series, NSF 64-11 (Washington: U.S. Government Printing Office, 1964), p. 51.

1958, and a doubling since 1960.) Table 1 compares these expenditures with the total budget of the Federal Government since 1940.

Figure 2 demonstrates the division of the Federal research and development dollar between intramural and extramural activities.[1] The growing influence of the Federal Government in the extramural area is readily apparent. The National Science Foundation has reported that in recent years almost three-fourths of all college and university research and development has been financed by the Federal Government.[2] The illustration shows that the major share of the increase has been in the industrial area. The aircraft, missle, electronics, and communications industries have literally grown up since the war under the aegis of the Government. Each of these industries has the requirement to develop the weapons of the nuclear and computer age. Each has received a large share of its research and development budget from the Federal Government.

This introduction to research and development serves as a further introduction to an integral part it--Scientific and Technical Information--which is both its starting point and its end-product. Research and development and scientific information

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[1] Intramural and extramural activities refer to the organization which performs a function or service in Federal scientific activity. Intramural activities are those performed by agencies of the Federal Government. Extramural activities perform research and development for the Federal Government under contract or grant. They may be either profit or non-profit.

[2] National Science Foundation, Federal Funds for Research, Development, and Other Scientific Activities, Vol. XII, Surveys of Science Resources Series, NSF 64-11 (Washington: U.S. Government Printing Office, 1964), p. 52.

Table 1.--Federal Government Research and Development Expenditures, Fiscal Years 1940-1964[a]
(millions of dollars)

Fiscal Year	Total Budget Expenditures	R&D Expenditures[b]
1940	$9,062	$74
1941	13,262	198
1942	34,046	280
1943	79,407	602
1944	95,059	1,377
1945	98,416	1,591
1946	60,448	918
1947	39,032	900
1948	32,955	855
1949	39,474	1,082
1950	39,544	1,083
1951	43,970	1,301
1952	65,303	1,816
1953	74,120	3,101
1954	67,537	3,148
1955	64,389	3,308
1956	66,224	3,446
1957	68,966	4,462
1958	71,369	4,990
1959	80,342	5,803
1960	76,539	7,738
1961	81,515	9,278
1962	87,787	10,373
1963(estimate)	94,311	12,226
1964(estimate)	98,802	14,979

[a]Source: National Science Foundation, Federal Funds for Research, Development, and Other Scientific Activities, Vol. XII, Surveys of Science Resources Series, NSF 64-11 (Washington: U.S. Government Printing Office, 1964), p. 52.

[b]Includes expenditures for research and development plant.

are inexorably tied together. A 1963 report concluded that: ". . . the attitudes and practices toward information of all those connected with research and development must become indistinguishable from their attitudes and practices toward research and development itself."[1] This observation represents the overdue trend toward admission of the close relation between science and information. The National Science Foundation has reported:

> Scientific and technical information is both principal ingredient and a major product of research and development. As science and technology have expanded, so have the volume and complexity of the interchange of scientific information. . . . The increased rate of scientific discoveries accompanied by their application through technology has also created an element of urgency in disseminating research results.[2]

In order to measure the relation further, figure 3 matches the Federal expenditures for each since 1960. Adequate data for years prior to 1960 are not available.

Definitions

In order to provide a clearer conception of important terms which will be used throughout this paper, several definitions[3] are listed below. Further definitions will be developed as required.

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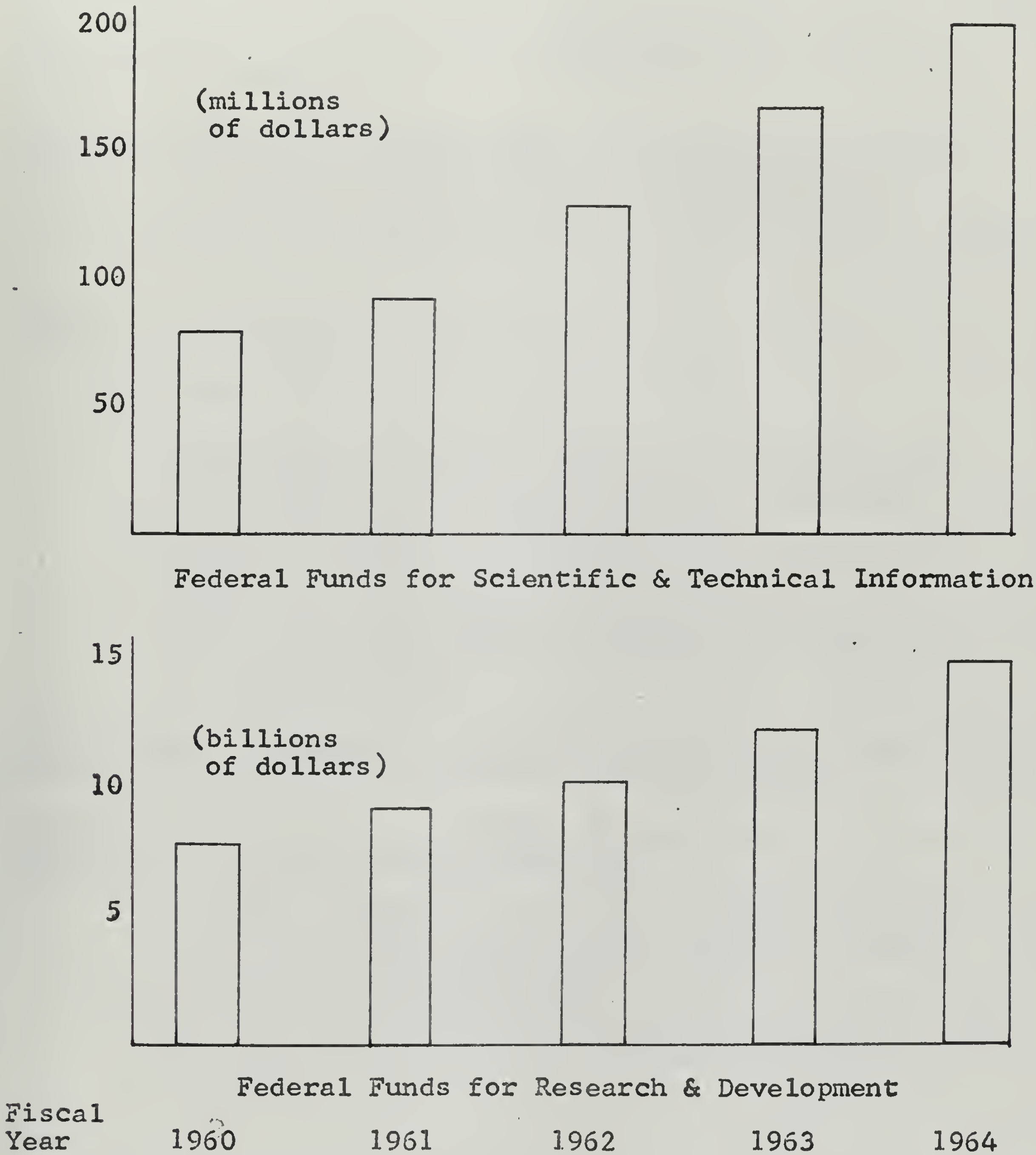
[1]U.S., Senate, Committee on Government Operations, Hearings on Interagency Coordination of Information, 87th Cong., 2d Sess., 1963, p. 14. Cited hereafter as The Humphrey Hearings after Senator Hubert H. Humphrey, Chairman of the Subcommittee on Reorganization and International Organizations.

[2]National Science Foundation, NSF 64-11, *op. cit.*, p. 56.

[3]All definitions except the last two were obtained from the National Science Foundation publication NSF 64-11, *op. cit.*, pp. 90, 92, 93, and 95. The definition of information storage and retrieval is quoted from Joseph Becker and Robert M. Hayes,

Figure 3.--Expenditures of Federal funds for research and development compared with obligations for scientific and technical activities. Fiscal years 1960-1964[a]



[a]Source: National Science Foundation, Surveys of Science Resources Series, 1962-4.

Research is systematic, intensive study directed toward fuller scientific knowledge of the subject studied. Such study covers both basic and applied research.

Basic research is that type of research which is directed toward increase of knowledge in science. It is research in which the primary aim of the investigator is a fuller knowledge or understanding of the subject under study, rather than as is the case with applied research, which is concerned with a practical application thereof.

Development is the systematic use of scientific knowledge directed toward the production of useful materials, devices, systems, or methods, including design and development of prototypes and processes. It excludes quality control, routine product testing, and production.

Science is divided into five fields: Life, psychological, physical, social, and "other" sciences.

Life Sciences are further separated into:

1. Biological sciences, apart from the medical and agricultural sciences defined below, deal with the origin, development, structure, function, and interaction of living things.
2. Medical sciences are concerned with maintaining health and understanding disease.
3. Agricultural sciences are directed primarily toward understanding and improving the production of animals and plants of economic and cultural importance to man.

Psychological sciences deal with behavior, mental processes and individual and group characteristics and abilities.

Physical sciences are the physical sciences proper, and the mathematical and engineering sciences.

1. Physical sciences proper are concerned primarily with the understanding of the natural phenomena associated with nonliving things.
2. Mathematical sciences employ logical reasoning with the aid of symbols and are concerned with the development of methods of operations employing such symbols.

Information Storage and Retrieval: Tolls, Elements, Theories (New York: John Wiley and Sons, Inc., 1963) p. 70. The last definition is quoted from Information Retrieval Management, ed. Lowell H. Hattery and Edward M. McCormack (Detroit: American Data Processing, Inc., 1962), p. 15.

[illegible]

[illegible]

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[illegible]

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- [illegible]
- [illegible]

[illegible]

[illegible]

- [illegible]
- [illegible]

[illegible]

3. Engineering sciences are concerned with studies directed toward developing scientific principles or toward making specific scientific principles usable in engineering practice.

Social sciences are directed toward an understanding of the behavior of social institutions and groups and individuals as members of a group. These include such sciences as cultural anthropology, economics, history, political science, and sociology. In addition to work in disciplines or subjects traditionally considered social science, it was intended that this field should also include work in other disciplines or subjects in which work was undertaken primarily for the purpose of understanding group behavior.

Other sciences is the category provided for reporting research which cannot be readily classified under one of the above-named fields.

Scientific and Technical Information.[1] Scientific and technical information is knowledge or data resulting from the conduct of research and development, or required for organizing, administering, or performing research and development. It encompasses any information in recorded or other communicable form, which presents the status, progress or results of research and development in science or technology, or which has potential use in advancing current and future research and development.

Excluded from this definition of scientific and technical information are: (1) Raw scientific and technical data that have not been processed for use by scientific personnel engaged in research and development; (2) statistical and general-purpose data that are collected and organized for other than specific use in research and development; (3) information that has been prepared primarily to inform or instruct the general public or others below the graduate or professional level of scientific activity.

Scientific and Technical Information Activities. Scientific and technical information activities include all management, administrative and operational efforts directed to the planning, support, control, performance and improvement of the functions or tasks which deal with the processing, handling and communication of scientific and technical information. Also included are the acquisition and maintenance or rental of special equipment for use primarily in scientific and technical information activities.

Information storage and retrieval consists of a four-cycle process:

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[1]For the purpose of this paper "scientific information" and "information" will be used interchangeably with the longer term "scientific and technical information."

1. Printed data are received and analyzed to determine which index terms are to be associated with the document.
2. An index code pattern is determined and the document is placed in a file.
3. A user interacts with the index and the file; to use the index he must employ certain logical processes.
4. He obtains ideas and facts from the system and eventually starts the cycle over again by generating a new document.

The main function of science documentation [is] . . . to arrange ways and means by which scientific information can best be collected, preserved, analyzed, indexed, abstracted, reviewed, translated, and interpreted, for two purposes: (1) that scientists generally might know what is going on; and (2) that people generally might understand something of what science is all about, and what it may mean to them in comfort, health, convenience, and satisfaction.

Current Attitudes

A striking, first impression one gets in studying the information problem is that scientists are not as concerned about the duplication of their research efforts as are administrators. This may appear to be a logical conclusion since "workbench" scientists are less likely to be concerned with bill-paying and other administrative matters than in their own fields of interest.

This attitude is shared by many administrators of research and development projects in and out of the Federal Government. General Arthur G. Trudeau, in 1961 while Chief of Research and Development of the U.S. Army, was quoted as hearing a leader of American Industry say that "If a research job costs less than $100,000 it is cheaper for us to do it than to find out if it has been done before and reported in literature."[1] The same thing

[1] The Humphrey Hearings, op. cit., p. 46, quoting an address by General Trudeau in 1961 to the American Management Association.

has been stated in similar terms by dozens of persons concerned with the communication of valid scientific information.

In a 1963 report, the President's Science Advisory Committee, stated that a "scientist resorts to the information system if he believes it is easier, or more illuminating, to consult the written record rather than to do the experiment himself."[1]

Calvin Mooers, a leader in documentation and information, restated the difficulty as Mooers' Law:

> An Information Retrieval System will tend not to be used whenever it is more painful and troublesome for a customer to have information than for him not to have it.[2]

The $100,000 figure cited above underlines the trouble industry is willing to undergo. If critical to National Defense, such a situation can have reverberations long afterward. The tragedy is perhaps best stated in John Milton's warning that: ". . . revolutions of ages do not oft recover the loss of a rejected truth, for the want of which whole nations fare the worse."[3]

Many scientists are concerned with this basic communication problem. Dr. Jerome B. Wiesner, former Special Assistant to the President for Science and Technology, was one of

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[1]U.S., The President's Science Advisory Committee, Science, Government, and Information, A Report, January 10, 1963, p. 10. Cited hereafter as the Weinberg Report after the Chairman of the Panel on Science Information, Alvin M. Weinberg.

[2]"Mooers' Law, or Why Some Retrieval Systems Are Used and Others Are Not," American Documentation, XI, No. 3 (July 1960) p. 204.

[3]Areopagitica (Chicago: Henry Regnery Company, 1949), p.4.

the most active men in government in trying to evolve a general policy on information handling among governmental agencies during his tenure. In testimony before a Senate Subcommittee, he said:

> Two simple, but essential points have emerged from our studies. First, scientific information is an integral part of research and development. Second, to cope with the ever-increasing flood of technical information, all those connected with R&D--Government agencies, technical societies, and individual scientists --will have to devote more thought, effort, and resources to technical information than in the past.[1]

Interdisciplinary Nature of Science

Aside from the basic fact that the whole structure of science is too vast for one person's comprehension, there is an increasing tendency for science specialties to become interconnected. Thus, medical science is no longer confined to biology and chemistry. Biophysics, bioastronantics, and bionics are ever-expanding sciences in their own right.

Dr. Saul Gorn, of the University of Pennsylvania, has made an astute observation concerning this matter.

> What happens is that there must be a balance, as the file grows, between the retrievability of the information and the needed communication flow of the information; the control of the information due to the structure of its arrangement must balance the method by which it is communicated. What has happened, then, is that the continuum of a domain of knowledge when a revolution is due, either splits into distinct fields or changes phase radically by a change in the structure of its arrangement. That is, once the mass of information got beyond the critical mass, usually either fission or fusion occurred. Fusion is the change in the structure of the individual science itself to make it a much more compact carrier of information; for example, general laws are highly compact bouillon cubes of information. Fission is the breaking

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[1]The Humphrey Hearings, op. cit., p. 24.

> up into various areas of specialization, which we have already mentioned. The fission or fusion occurred in each case because the information got beyond our capacity, and its former control began to require too much time to retrieve the information, you either have to have separate specialized lumps or have a violent change in structure.[1]

As an example of the interrelatedness of research and development, a task force reported to Dr. Wiesner in 1962:

> . . . research on detection of infrared radiation is related to the field of optics since it deals with optical radiation; to the field of solid state physics by virtue of its contribution to understanding of solid state; to chemistry by virtue of its potential contribution to spectrometric analysis of structure and composition; to instrumentation as a contribution to the transducer art; to communication by means of infrared radiation; to missle guidance; to aircraft safety; to control of space vehicles; to military surveillance; to criminal investigation; to identification of works of art; and to innumerable other areas and in ways not yet conceived.[2]

The Weinberg Report underlined "the danger of science fragmenting into a mass of repetitious findings, or worse, into conflicting specialties that are not recognized as being mutually inconsistent."[3] In pursuing this point further the report demonstrates the plight of National Aeronautics and Space Administration scientists and engineers, not only in communicating their knowledge to others interested in space activities, but to chemists and physicists in other specialized fields.[4] Thus, even

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[1] "Computers, Communications and Science--Extending Man's Intellect," Information Retrieval Management, op. cit., Ch. 17, p. 126.

[2] Scientific and Technological Communication in the Government, a Task Force Report to the President's Special Assistant for Science and Technology, James H. Crawford, Jr., Chairman, 1962, p. 8. Cited hereafter as the Crawford Report.

[3] The Weinberg Report, op. cit., p. 7.

[4] Ibid., p. 15.

though scientists choose ever-narrowing disciplines in which to specialize, they must maintain close contact increasingly with diverse parts of the literature.

Another facet to the interdisciplinary nature of science was pointed out by Dr. Eugene Garfield who noted that not only physical sciences but the behavioral sciences--psychology, communication, linguistics, and sociology--have a great need for more study.[1] Dr. Garfield also pointed out that there are some people who still dispute whether science is interdisciplinary.

> Any specific area in technology, while it is very important, is not of greater concern to me; but rather the man who is working in the interdisciplinary field will produce the idea that leads to a transistor, a polio vaccine, et cetera. That is why we need a highly coordinated, centralized approach.[2]

The Products of Science

There are varying estimates of the current composition of the world's technical literature. The following list, which was made by the Stanford Research Institute, provides a rough indication of the outpouring of scientific knowledge which takes place each year:

	TOTAL
Responsible Technical Journals	30,000 to 50,000
Articles Published Annually	500,000 to 2,000,000

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[1]U.S., House of Representatives, Committee on Education and Labor, National Information Center, Hearings before an Ad Hoc Subcommittee on H.R. 1946, I, 88th Cong., 1st Sess., 1963, p. 250-1. Cited hereafter as The Pucinski Hearings after the Chairman, Congressman Roman C. Pucinski

[2]*Ibid.*, p. 240.

Technical Books Published Annually 60,000

Documents issued by U.S. Government 100,000 to 150,000[1]

Dr. Derek Price, in his book Science Since Babylon,[2] observed that the first scientific journal was published in 1665. One hundred years later the number had grown to ten. Since then the technical journal has been growing by powers of ten about every fifty years. Thus, the ten journals in 1750 grew to one hundred in 1800, one thousand in 1850, and ten thousand in 1900. Dr. Price, as well as many others, is horrified at the prospect of one million journals by the year 2000 if present trends continue (see figure 4).

As a sidelight to the basic problem, there is the fact of the growth of the abstract journal. First started in the mid 1800's, over three hundred exist at the present time.

Another aspect of the scientific literature is the lessening of importance of the English language as the language of science. Dr. Burton W. Adkinson, of the Office of Science Information Service, National Science Foundation, has estimated that seventy per cent of the published literature in science and technology originates outside the United States and fifty per cent appears in English.[3] Of significance is the inability of American scientists to read foreign languages, in contrast to the

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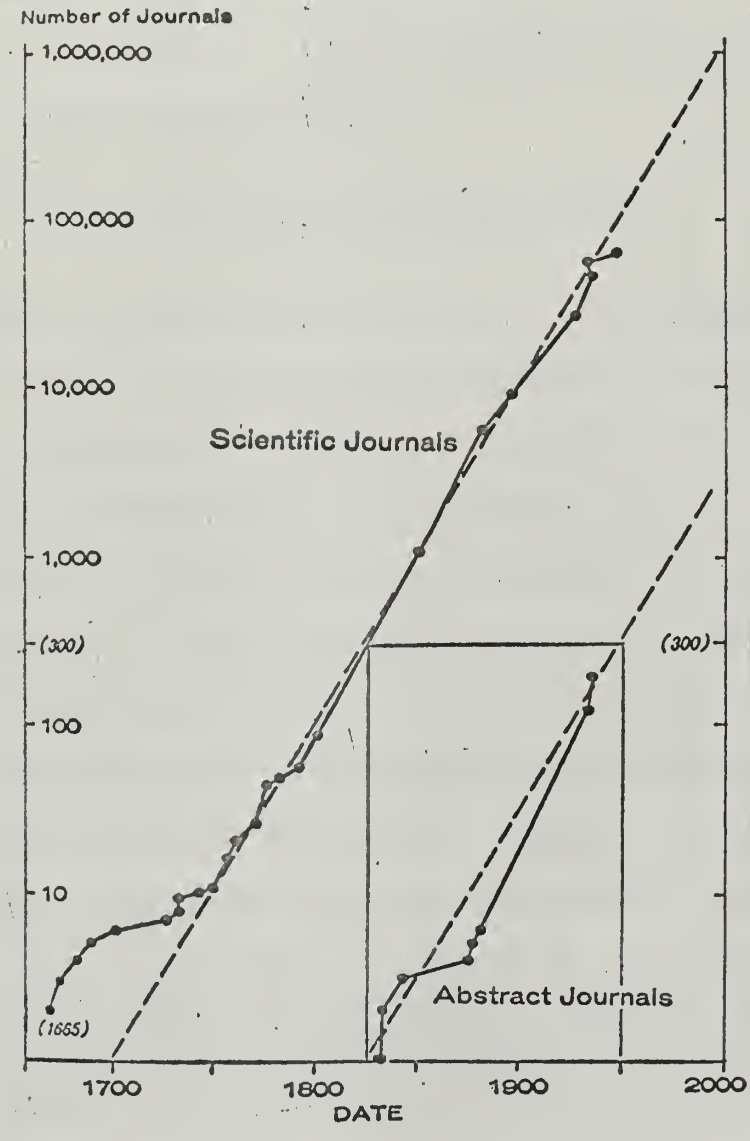
[1] "A Draft Program for a National Technical Information Center," prepared by Stanford Research Institute, Ibid., Appendix, p. 5.

[2] Derek J. de Solla Price, Science Since Babylon (New Haven: Yale University Press, 1961), pp. 95-99.

[3] The Pucinski Hearings, op. cit., p. 22.

Figure 4.--Growth of Scientific Journals and Abstract Journals Since 1665.[a]



[a]Source: Derek J. de Solla Price, Science Since Babylon (New Haven: Yale University Press, 1961), p. 97.

multilingual facility of many foreign scientists. For instance, Dr. Adkinson estimated that:

> Over 50 percent of the scientists in Russia read and understand the English language. . . . Where about 2 percent of our scientists and engineers read and understand Russian.[1]

Consequently, unless adequate and efficient translation services are made available, American science will be at an increasingly dangerous comparative disadvantage.

The Scientist's Responsibility

So far the information problem has been examined as it exists today. There is little disagreement as to its existence. The problem has been rather in the ways in which the scientific and engineering communities are to deal with it. The information problem is a product of the advances of science; the scientist remains indispensable to the scientific equation. However, science always needs new ideas and new information. The results of scientific research must not overshadow the obligation to contribute useful knowledge to science. Doctor Samuel Johnson, in discussing the problem of knowledge in general, said:

> Human experience, which is constantly contradicting theory, is the great test of truth. A system, built upon the discoveries of a great many minds, is always of more strength, than what is produced by the mere workings of any one mind, which, of itself, can do little.[2]

The information problem, then, exists in several ways:

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[1] *Ibid.*, p. 23.

[2] James Boswell, *The Life of Samuel Johnson LL.D.*, (New York: The Modern Library, /1791/), p. 274.

(1) there is more literature than can be read by any one man in any one discipline; (2) there is a tendency to duplicate research because of the difficulty in locating existing research reports; (3) the scientific community is well aware of the problem but has been unable to make satisfactory solutions; (4) foreign language literature may be of equal importance to the scientist; (5) there is concern for the problem at the executive and legislative levels of the Federal Government; and (6) there is no satisfactory coordination of ideas on how to solve the problem.

CHAPTER II

EXISTING CENTERS AND SERVICES

Introduction

So far the larger problems of information handling have been dealt with in a generalized way. In order to focus attention on the situation which the scientist faces it is necessary to review the services which are available today.

Strauss, Strieby, and Brown, in their book Scientific and Technical Libraries: Their Organization and Administration,[1] list seven general locations for these services:

1. Industrial Organization.
2. Academic Institution.
3. Public Library.
4. Professional Association.
5. Research Institute.
6. Government Bureau or Other Division.
7. Hospital.

These services occupy a variety of locations within their respective organizations. Some may be centralized and service many departments; others will serve only a specialized segment of their organization.

The above grouping can also be separated into two categories: (1) the internal center, which serves the needs of

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[1] L. J. Strauss, I. M. Strieby, and A. L. Brown (New York: John Wiley and Sons, Inc., 1964), pp. 6-7.

one organization or company; and (2) the general center, either commercial, academic, or governmental, which serves a wider audience. Services of this latter type are generally provided on a fee, subscription, pro-rata, or tax support basis. The expense of the former type is generally absorbed as operating or overhead cost of the parent organization.

The number of general services in existence today is considerable. A 1963 report by the National Federation of Science Abstracting and Indexing Services lists 1855 separate services available in forty countries. The report also mentions that 1300 other services are not listed due to space limitations.[1]

Existing centers provide a variety of services. The following is a listing of the most common functions:

1. Collection of publications.
2. Maintenance of special subject references, files, and indexes.
3. Dissemination of current information.
4. Circulation of books and routing of periodicals.
5. Keeping specialized technical files.
6. Maintenance of reference service.
7. Compilation of bibliographies and organization of reports.
8. Editorial assistance with publications.
9. Translation services.
10. Other personalized services.[2]

This listing is a general one. Many of these services are not available due to budgetary, personnel, or other limitations. Thus these services listed above represent an optimum. Such

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[1] A Guide to the World's Abstracting and Indexing Services in Science and Technology, Report No. 102 (Washington: National Federation of Science Abstracting and Indexing Services, 1963), p. vi.

[2] Strauss, Strieby, and Brown, op. cit., p. 15.

services are available at only a few forward-looking organizations throughout the country. One of the points of this paper is that until such service is widely available national scientific and technological programs will suffer considerably.

Centers are gradually shedding their images as libraries and are attempting to emphasize their role as more aggressive purveyors of useful and timely information. J. H. Heald has stated that "we must make the information go to the man"[1] rather than relying on passive methods of old. The word "library" is losing importance in favor of such descriptions as "information service" and "information center." The latter descriptions also connote the idea of information being actively "processed" for the ultimate user rather than being merely stored.

This distinction is important for another reason: the information center must have a staff which is able to communicate in the specialized language of the user. The personnel problems inherent in this concept are formidable and will be developed in Chapter IV.

Dr. James Shannon, Director of the National Institutes of Health, summarized a widespread general feeling in relating why his organization was not using its library as the focal point of a large modernization program of information activities:

> . . . the primary reason we did not turn to the library at this time is that we feel that the type informational activity we envisage as being operative within a year or two will be highly technical and will require for its administration the highest level of professional scientific competence that we can spare. The library services would become a small

[1] J. H. Heald, *op. cit.*, p. 41.

> part of a much vaster network of scientific communication, rather than assume this larger task within itself.[1]

Sources of Information

The reason for storage and accumulation of information is to assist the scientist in some way. From the user's point of view there are three basic sources of documentary data: abstract and index journals, original content journals and papers, and books. Stated another way these sources may be described as, primary and secondary. Primary sources are those original works which appear in such form as journals, papers, books, reports, dissertations, etc. Secondary sources are the abstract and index journals.

Secondary Sources.--In a 1963 study prepared for the National Federation of Science Abstracting and Indexing Services, a management consultant firm[2] distinguished between two types of secondary publications needed by a scientist or engineer: profession-oriented and project-oriented. Profession-oriented services are those whose goal is "to cover on a comprehensive and continuing basis the world's literature in one or more of the traditional fields of science."[3] The study found that eighteen services such as, Biological Abstracts and Engineering Index, qualified as profession-oriented. These publications are

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[1]The Humphrey Hearings, op. cit., p. 127.

[2]Robert Heller and Associates, Inc., A National Plan for Science Abstracting and Indexing Services, Report to the National Federation of Science Abstracting and Indexing Services (Cleveland: 1963), p. 3. Cited hereafter as the Heller Report.

[3]Ibid., p. 12.

characteristically "large and space consuming because they are retained on a permanent basis,"[1] expensive, and used mostly for retrospective searching. Despite the number of services of this type, the study found that: "An analysis of 17,000 primary journals covered by 11 of the eighteen services in 1961 showed about 50% overlap in journal coverage."[2] The report concluded that profession-oriented services needed cooperation among services and improvement of their coverage in order to solve imminent financial problems.

The Heller Report found the project-oriented services in no less a predicament. Project-oriented services are those whose goal is "providing comprehensive coverage of significant information for a particular project area or subject, and selection of articles therefore may be from literature in any field of science or technology."[3] These services number approximately 270 and account for almost a million and a half citations per year. The Heller Report found that the services are not satisfactory because of: poor quality abstracting, inadequate literature coverage, poor indexing, lack of timeliness, and failure to provide expected service. The current features of these services is their relative inexpensiveness, greater selectivity, and large growth potential.

Government Services

Any study of the information dissemination problem invariably centers around the activities of the Federal

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[1] Ibid., p. 14. [2] Ibid., p. 16. [3] Ibid., p. 18.

Government. Since the government undertakes three-fourths of the research and development expenditures in the country it follows that it is by far the largest user of information activities too. For this reason the activity of the Federal Government in managing its information systems will be the focal point of this study. As will be seen there are many prime examples of the duplication of effort which characterizes the whole information industry.

In order to gain an understanding of the role of the Federal Government the following points will be covered: (1) the origins and evolution of the information functions; (2) the departments and agencies involved; (3) criticisms which have been leveled; (4) recent trends in improvement of the management of information; and (5) the services which are provided.

Origins and Evolution

Although scientific and technical information has been important in the structures of various Departments of the Federal Government for many years (e.g. patents), the starting point in recognizing its management problems has been generally considered as the creation of the National Science Foundation in 1950. Originally the act was introduced into the Senate in 1947 (S. 493, 80th Congress) to provide in part for coordination and more efficient administration of scientific and technical information. Its objectives were to continue wartime scientific programs and to get war-developed information disseminated more efficiently. Starting a tradition which has generally continued

to this day, scientists and industry provided much opposition to the bill.[1] The result was the National Science Foundation Act of 1950 which authorized and directed the Foundation "to foster the exchange of scientific information between scientists in the United States and foreign countries"[2] and "to publish or arrange for the publication of scientific and technical information so as to further the full dissemination of information of scientific value consistent with the national interest . . ."[3]

It is very important to the whole scientific information question to understand the choice available to the National Science Foundation founders. More active and broader interpretation of the statute at the start could have provided an impetus to scientific communication at a time when the mandate would not have been disputed. However, the Foundation chose to restrict their authority to merely encourage scientists to meet and discuss mutual problems. The membership of the Board of the National Science Foundation actually consigned it to an advisory capacity from the beginning because of its dominance by scientists (in accordance with the law) who fought any trend toward Federal control of science.

In 1958 the National Defense Education Act gave the Foundation more responsibility in scientific information through

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[1] U.S., Senate, Committee on Government Operations, Documentation, Indexing, and Retrieval of Scientific Information: A Study of Federal and Non-Federal Information Processing and Retrieval Programs, Document No. 113, 86th Cong., 2d Sess., June 23, 1960, p. 3.

[2] U.S., Congress, National Science Foundation Act of 1950, Public Law 507, 81st Cong., 2d Sess., 1950, Sec. 3. (a) (5), p. 1.

[3] Ibid., Sec. 11. (g), p. 4.

creation of a Science Information Service to "provide, or arrange for provision of indexing, abstracting, translating, and other services leading to a more effective dissemination of scientific information, and . . . undertake programs to develop new or improved methods, including mechanized systems, for making scientific information available."[1] The act provided for the Science Information Council "to advise, consult with, and make recommendations to the head of the Science Information Service."[2]

A final responsibility was placed--by Presidential directive in 1959--on the National Science Foundation to take the "leadership in the effective coordination of the scientific information activities of the Federal Government with a view to improving the availability and dissemination of scientific information."[3]

In this same directive, action was taken by President Eisenhower to create the Federal Council for Science and Technology for the purpose of "planning and administration of Federal scientific and technological programs."[4]

Thus, in toto, the Foundation possesses the legal authority to become quite powerful in scientific information activities. However, Dr. Burton W. Adkinson's testimony before

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[1]U.S., Congress, National Defense Education Act of 1958, Public Law 864, 85th Cong., 2d Sess., 1958, Title IX, Sec. 901.

[2]Ibid., Sec. 902 (b).

[3]U.S., President, Federal Council for Science and Technology, Executive Order 10807, Sec. 6 (Washington: The White House, March 13, 1959), contained in 3CFR, 1959-1963 Comp., p. 331.

[4]Ibid., Sec. 2, p. 330.

the Pucinski Hearings is very illuminating in understanding the basic thinking at the National Science Foundation:

> . . . it [the law] said that the National Science Foundation should expand its scientific information program to strengthen, not supplant existing services; coordinate, not operate . . .[1]

Later at the same hearings, he said:

> But no matter what you do in terms of giving a Government agency more authority, you can't force them or you can't have them force these myriads of non-Government organizations to cooperate or to do the things.
>
> We are getting a great deal of cooperation where we were not before. The cooperation is improving very rapidly. The abstracting-indexing services are beginning to work together. The scientific associations are talking together. The Government agencies are cooperating in their work. In no case can any one Government agency order another Government agency to do anything. The only person that can do this is the President. He can give you authority to set down certain rules and regulations. What I am saying is, yes, there needs to be more support in this area. There needs to be more coordination. I do not have the formula on how to put this together beyond persuasion.[2]

Thus, the National Science Foundation felt it lacked the administrative authority to fully carry out its legal authority.

The Federal Council for Science and Technology was making some progress in getting the agencies to recognize the need for elevating the status of scientific information activities in the agencies. In June 1962 a Council of Scientific Information was formed. It is a permanent working committee to foster inter-agency coordination of standards among government information systems. The Council of Scientific Information is composed of

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[1]The Pucinski Hearings, op. cit., p. 24.

[2]Ibid.

the top science information officials in the various agencies most involved in science and technology. Dr. Wiesner, in testimony at the Humphrey Hearings, also reported that a new direction was taken by the Council:

> At the same time, the Council established a Committee on Scientific and Technical Information to develop Government-wide standards and assure compatibility between agency systems, and I do intend to follow this very aggressively myself.[1]

In 1962 an effort was made to coordinate Federal information systems even more through the creation of an office of Science and Technology in the Executive Office of the President. This action formalized the existence of a Presidential science advisory staff. In the words of Dr. Wiesner, its Director, the Office of Science and Technology:

> . . . is responsible for providing policy guidance in the matter of scientific and technical information, but it does not have the authority to impose central direction and control. The Office has a professional staff member devoting full attention to this field.[2]

The foregoing has been a brief sketch of the development of science information management at the upper echelons of government. Although it is impossible to cover all the activities of all Federal agencies, the next two sections will develop some of the diversity which is involved in scientific information systems in terms of both agency requirements and missions, and in services which are provided.

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[1]The Humphrey Hearings, op. cit., p. 28.

[2]Ibid.

The Administering Agencies, Improvements and Criticisms

There are many differing estimates on the extent to which many of the agencies are engaged in scientific information activity. Basically there are seven departments: Agriculture; Commerce; Defense; Health, Education, and Welfare; Interior; Labor; and State; thirteen other agencies are also involved. However, within the seven departments mentioned above, a total of forty-six separate bureaus sponsor some recognizable information activity either in-house or under contract.

As an indication of the scope of the major information activities Table 2 shows the relative distribution by agency of the Federal obligations for scientific and technical information for the fiscal years 1962-64. The nine agencies named account for over ninety-five per cent of all Federal activity in this field.

A recent compilation, Table 3, of the number of information activities under Federal sponsorship is revealing. As an indication of the number, the Defense Department estimated in 1962 that it supported one hundred specialized information centers, either in-house or under contract.[1] Table 3 shows that the involvement of the Defense Department is even greater now, totaling one hundred forty-two. The table shows subtotals for the Defense Department and for the National Institutes of Health. The totals for each agency are further divided into in-house and those under contract or grant which are either profit or non-profit, that is, affiliated with colleges or universities.

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[1] *Ibid.*, p. 73.

Table 2.--Obligations for scientific and technical information, by selected agency, fiscal years 1962-64.[a]

Agency	Actual 1962	Estimates 1963	Estimates 1964
Total, all agencies (millions of dollars)	$129	$167	$201
	Per cent distribution		
Department of Defense	29	32	30
Department of Commerce	22	19	19
Department of Health, Education, and Welfare	19	17	18
National Aeronautics and Space Administration	6	8	9
National Science Foundation	8	7	8
Library of Congress	5	4	4
Department of Interior	4	4	4
Atomic Energy Commission	3	3	3
Department of Agriculture	3	3	3
All other agencies	2	3	2

[a]Source: National Science Foundation, Federal Funds for Research, Development, and Other Scientific Activities, Vol. XII, Surveys of Science Resources Series, NSF 64-11 (Washington: U.S. Government Printing Office, 1964), p. 62.

Note: Detail may not add to totals because of rounding.

Table 3.--Federal Scientific and Technical Information Facilities, 1964[a]

Departments & Agencies	No. of Offices	In-house	Non-profit	Profit
Agriculture	17	17		
Commerce	17	15	2	
Defense, Total[b]	142	109	24	9
Office of Secretary	(31)[c]	(10)	(18)	(3)
Army	(42)	(40)		(2)
Navy	(48)	(42)	(4)	(2)
Air Force	(21)	(17)	(2)	(2)
Health, Educ., & Wel.	40	18	21	1
Nat. Inst.of Health	(26)	(6)	(19)	(1)
Interior	7	7		
Post Office	1	1		
State	1	1		
Atomic Energy Comm.	10	1	3	6
Arms Control Agency	1	1		
Civil Service Comm.	1	1		
Federal Aviation Agcy.	3	3		
Fed. Communications C.	1	1		
NASA	12	8	2	2
Nat. Science Found.	3	1	2	
Smithsonian Inst.	1	1		
Library of Congress	2	2		
Total	259	187	54	18

[a]Source: U.S., House of Representatives, Select Committee on Government Research, Statistical Review of Research and Development, Study No. IX, H.R. 1940, 88th Cong., 2d Sess., December 28, 1964, p. 181.

[b]Some activities under military services actually perform service-wide information functions.

[c]All figures in parentheses are subtotals.

Identification of the cost of scientific information has, until recently, been unavailable. It was not until 1962 that the National Science Foundation began to identify scientific information expenditures separately in its annual science resources survey reports.

Likewise, the Bureau of the Budget first recognized the importance of these funds with a special analysis in the fiscal year 1964 budget document. Of significance is the section entitled "Science Information:"

> Increased attention is being directed to the adequacy of individual agencies' science information programs and particularly to their coordination with related activities of other agencies. Furthermore, the agencies are continuing their efforts to obtain additional and more reliable cost data on science information activities, a task made difficult because information handling is so closely integrated with other elements of particular research and development programs.
>
> The budgetary data available for fiscal year 1964 together with future agency planning demonstrates a growing recognition of the importance of science information to the research and development effort of the Nation. Substantially increased research and development is programed for scientific communication and documentation including methods of information retrieval, storage and dissemination, machine translation, and advanced mechanization techniques. Considerable increases are also planned for the publication and distribution of documents for bibliographic and reference services, including abstracting and indexing services. Likewise, there are some increases programed for scientific symposia and technical meetings, representing an orderly growth in this form of information exchange.[1]

Senator Hubert H. Humphrey, in commenting on this subject, has underlined one of the major management problems of, not only

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[1] U.S., Executive Office of the President, The Budget of the United States Government For the Fiscal Year Ending June 30, 1964, Special Analysis "G" (Washington: U.S. Government Printing Office, 1963), pp. 405-6.

our lawmakers, but also our agency administrators and budget officials:

> We have examined the records of the Appropriations Committees of the House and Senate, and there is a dearth of comment or estimate relating to information except as regards, for example, information activities of the Library of Congress, the Office of Technical Services, the National Library of Medicine, and the Science Information Exchange.
>
> Otherwise, when the main agencies come in, there is very little reference made to their information activities, as such.
>
> It seems to me this is one of the reasons why the services may very well be a little bit behind the times and behind the needs, simply because Congress has never been alerted to this. . . . It seems to me we could demonstrate in these agencies that information services, even though they may be listed out as a line item at a certain number of dollars, actually contribute to genuine economy or at least the economical utilization of research and development knowledge that is already nominally available.[1]

Department of Defense[2]

As shown in Table 2, page 36, the Defense Department is the governmental leader in science information activity. This lead evolved as an adjunct to its activity in research and development rather than as a primary mission. In late 1962 the Department created a new office under the Director of Defense Research and Engineering entitled the Defense Director of Technical Information. Department of Defense Directive 5100.36, in late 1962, established the office and provided for "the coordination and management of the DOD Scientific and Technical Information Program . . ."[3] The directive established an

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[1] The Humphrey Hearings, op. cit., pp. 93-4.

[2] Quotations in this section contain various abbreviations for the Department of Defense; namely, DOD, D.O.D., DoD.

[3] U.S., Department of Defense, Department of Defense Technical Information, DOD Directive No. 5100.36, dated December 31, 1962, para. 3A.

unequivocal policy of: (1) exchange of technical information both within the Department and between all Federal contractors, other Federal agencies, the scientific and technical community, and the Department; (2) use, where indicated, of computers and other modern information methods; (3) elimination of needless duplication of effort and resources.

More specifically, the Director of Technical Information coordinates the decentralized information activities operated and administered throughout the Department of Defense. The directive states: "In support of this structure provision will be made for centralized documentation and 'clearinghouse' functions as required to meet DoD-wide administration and technical needs."[1]

Thus the Department has taken a step in managing its information activities. It did not arrive at its present position without considerable prodding. In a scathing report early in 1962 Senator Humphrey provided a major share of the stimulus to improve scientific communication in the Department. In scoring the absence of Department-wide surveillance of information activity, he reported:

> There is at present inadequate organization, interest or responsibility for management of scientific and technical information at the D.O.D. level. . . .
> There is at present a Defense Supply Agency, a Defense Intelligence Agency, a Defense Communications Agency, but virtually no Defense-level unit for Department-wide information.
> The three services have separate r. and d. information programs which bear little organic relationship

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[1] Ibid., para. 4B.

to one another. There is virtually no coordination at the level of the Office of the Secretary of Defense.

In my view, a small information unit should be established in the Office of the Director of Defense Research and Engineering, in order to evaluate, coordinate and monitor the information activities of the Services. Such [a] . . . unit would help advise the Secretary on what the Department's future information role should be. It would help coordinate the Services' letting of contracts for information and documentation research, as well as D.O.D.-liaison with the National Science Foundation and other sources involved in Federal information policies. . . .

It is a paradox that a Department which has two million men under arms and one million civilians attempts to supervise the flow of scientific and technical information at the highest level through the services, at present, of one-half of one man-year in the Office of the Director of Defense Research and Engineering.[1]

Later in the same report Senator Humphrey revealed estimates which had come to him informally from various Department of Defense sources:

. . . about one-half the effectiveness of the engineers and scientists making our weapon systems may now be lost because they cannot get the information which they need at the right time, in the right way, and in the right place.

In terms of the technical manpower working on D.O.D. weapon system, this loss may be slashing around 150,000 man-years from the total effort of around 300,000 scientists and engineers.

This loss may represent between $1 billion and $2 billion each year. In terms of lost time, it may add one year to the 5-year development cycle of a weapon system. . . . No matter how much the contractors spend, or how able or diligently they go about the task, they cannot possibly find all the Federal report-type information which they need and when they need it. As a result, contractor scientists and engineers needlessly

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[1]Memorandum from Senator Hubert H. Humphrey, Chairman, Subcommittee on Reorganization and International Organizations, Committee on Government Operations, to Hon. George H. Mahon, Chairman, Subcommittee for the Department of Defense, House Committee on Appropriations, "The Department of Defense and Scientific and Technical Information," (Code Ident. S-3-11-62), Washington, March 26, 1962 (mimeographed), p. 10.

> repeat work which has been done before, or which is being unknowingly done at the same time, in other locations, or on which there might have been a short cut if ideas had been properly crossfertilized.[1]

Department of Commerce

This Department, second in science and technical information activity in the Federal Government, was the leader in information activity until 1962. The Department supports a total of seventeen separate information offices, fifteen in-house and two under contract. Three in-house subdivisions account for approximately ninety-seven per cent of the Department's expenditures each year: The Patent Office, the National Bureau of Standards, and the Office of Technical Services.[2] The Patent Office and Office of Technical Services operations are primarily public-oriented; the National Bureau of Standards supports eleven Department-oriented activities.

The Patent Office has the immense job of collecting and classifying all U.S. patents and many foreign patents, and the dissemination of scientific reports and patent data throughout the world. The Office is in the midst of an attempt to mechanize its search operations. The problem facing the patent examiner differs greatly from the search problem of the scientist. Ezra Glaser, Assistant Commissioner of the Patent Office, has said:

> . . . with the Patent Office . . . we have to be able to afford a thorough search. A scientist might decide that he has reached the point where it will take a lot of extra time to find anything else worthwhile. Therefore, the economics of his situation is that he cuts off his examination of the literature

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[1] Ibid., p. 15.

[2] National Science Foundation, NSF 64-11, op. cit., p. 62.

at a time convenient to him, depending on how valuable he thinks the information will be that might turn up.[1]

The interdisciplinary problem crops up here almost as a matter of course. Mr. Glaser, in reporting the patent classification problem, said:

> You pick up something that looks like a chemical patent and on page 3 you find yourself in the middle of an electronic control system to control the mechanical devices that handle the chemical reaction. Or else there are hydraulic principles involved in the system; you could equally well say that the patent belongs in chemical classification, electrical, mechanical, or hydraulic classification.[2]

Thus the three million patents in effect add up to ten million because of the necessity of detailed cross-classification. The management of the Patent Office has a task of devising a means to mechanize its operations, or to fall even further behind on its backlog of applications which in May 1963 totaled two hundred thousand, or almost three years processing time.

The dichotomy which exists between the top administrators and the persons who must operate information systems is well-demonstrated by Commissioner Glaser. The Patent Office has a limited number of file items and a definite storage and retrieval objective. Yet through some combination of technical limitation, administrative discretion, and budgetary restraint, mechanization was until recently being treated on a piecemeal basis. The technical limitation is not with computers, but with the methods of storing the vast information in retrievable form. However, the Patent Office has not led in correcting its dilemma.

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[1] The Pucinski Hearings, op. cit., p. 105.

[2] Ibid., p. 106.

Until recently the Office of Technical Services was perhaps the most fortunate beneficiary of the attention which has been heaped on the scientific information problem during the past few years. However, the Office was dormant for a number of years after its creation. The Office of Technical Services was established in 1951 pursuant to a law which directed the Department of Commerce "to establish and maintain . . . a clearinghouse for the collection and dissemination of scientific and technical, and engineering information"[1] for agencies of the Federal Government, state and local governments, and business and industry. John Green, in 1962 while Director of the Office of Technical Services, testified at the Pucinski Hearings that despite specific legislation:

> . . . we did not accelerate our activities during most of the 1950's. As a matter of fact, during this period we concentrated on the government research program, making available especially to the business community, the unclassified results of Government-sponsored research.[2]

In an exchange with a member of the Pucinski Subcommittee, Mr. Green revealed the gap between program objective and practice:

> Mr. Brademas: Where have you been hiding? We have not heard very much about it /Office of Technical Services/ across the Republic, I can tell you that.
>
> Mr. Green: Our timing was bad. We were too soon. I think it is important to do things at the proper time. Now there is a great deal of recognition of science information. In 1951 there was not.[3]

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[1]U.S., Congress, An Act to Provide for the Dissemination of Technological, Scientific, and Engineering Information to American Business and Industry, and for Other Purposes, Public Law 776, 81st Cong., 2d Sess., 1950, p. 1.

[2]The Pucinski Hearings, op. cit., p. 62.

[3]Ibid., p. 75.

As stated above, the Office enjoyed a period of ascendancy. In 1962 it was first strengthened and placed under the Assistant Secretary for Research and Development. Previously it had been a part of the Business and Defense Services Administration. However, the Office was absorbed, in the fall of 1964, into the National Bureau of Standards, another bureau of the Commerce Department, and renamed the Clearinghouse for Federal Scientific and Technical Information.

The National Bureau of Standards has emerged as a new force in promoting the development of science information. In addition to the recent transfer of the Office of Technical Services, the Bureau is almost ready to move into modern quarters at Gaithersburg, Maryland. With its new plant it is expected that the Bureau will ". . . selectively package and distribute technical information to the specific industrial segments which can best utilize it and to provide information on current research activities in order to reduce duplication of technical work."[1]

Department of Health,
Education, and Welfare

The interest of this department in scientific information is related principally to the Public Health Service which accounts for ninety-seven per cent of the total, and more specifically, to the National Institutes of Health. The National Institutes are composed of seven institutes and several divisions

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[1]U.S., Executive Office of the President, The Budget of the United States Government For the Year Ending June 30, 1966, Appendix (Washington: U.S. Government Printing Office, 1965), pp. 235-6.

which conduct research and disseminate scientific information on their specialized fields, such as mental health, cancer, dental, heart disease, and arthritis.

Management of scientific information has improved considerably. In a 1962 memorandum, the Director of the National Institutes, Dr. James Shannon, advised the Surgeon General, Dr. Luther Terry, of changes which had been made to provide bureau-wide coordination.[1] The eleven point program is summarized below as an example of conditions which had been allowed to exist and the improvements which were to be facilitated by the move:

1. Establish a scientific communication officer in each institute and division to manage Institute or Division scientific and technical communication.

2. Establish an Office of Research Information directly under the Director to coordinate all Institute activities in this area.

3. Establish an Institute Committee on the Management of Drug Information to consider methods to better correlate information on drugs both internal and external to the Institutes.

4. Develop a formal pattern of relationships with the Food and Drug Administration.

5. Develop categorical information centers in each of the Institutes and Divisions which would cover the respective specialty fields.

6. Assign to the Division of Research Facilities and Resources responsibility in support of the biomedical communications process through extramural programs.

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[1]Memorandum from Dr. James A. Shannon, Director, National Institutes of Health, to Dr. Luther Terry, Surgeon General of the U.S., "NIH actions in the field of scientific and technical communications," Washington, September 20, 1962, quoted in entirety in The Humphrey Hearings, op. cit., pp. 128-31, as Exhibit 11.

7. Develop a program of information centers.

8. Use the National Academy of Science--National Research Council in assessing the problems of communication among working scientists in the biomedical area.

9. Continue support of medical conferences, seminars, and symposia for the development of interchange programs both domestically and internationally.

10. Further develop support of the publications in conjunction with the National Library of Medicine.

11. Improve Institute indexing and documentation of grant activities relating to research projects.

A second agency which has taken the lead in improving management of its science information activities is the Food and Drug Administration. Until prodded by Congress, and backed by administration officials, this activity had been unable to adequately perform the important function of food and drug regulation. The trend is clearly upward as evidenced by the recent expenditures for information services which have risen from $137 million in 1962 to $309 million in 1964.[1]

More recently, the Food and Drug Administration has started to completely overhaul its science information capability. The industrial research and engineering firm, Arthur D. Little, Inc., has developed a plan to computerize and centralize its files of scientific data which heretofore had been separately maintained by each of five bureaus. A recent article[2] in Chemical and Engineering News described features of the system

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[1]National Science Foundation, NSF 64-11, op. cit., p. 160.

[2]"FDA Revamping Its Scientific Data System," Chemical and Engineering News, XLII, No. 37 (September 14, 1964), pp. 32-4.

which is expected to be operational in 1968 at an installation cost of $4 million. These features are as follows:

1. Division of information into four sub-systems: therapeutic devices; food, drug, and cosmetics; hazardous substances; adverse reaction and hazardous substances reporting.

2. Cross-indexing of these sub-systems by Central Retrieval Index which thus provides control of inputs.

3. Communications links between the central computer and eighteen field offices.

Figure 5 demonstrates the various inputs and outputs of the new system.

Other important centers located within the organizational structure of the Federal Government are:

Department of Defense
  Defense Documentation Center

National Aeronautics and Space Administration
  Office of Scientific Information

Atomic Energy Commission
  Office of Science Information Service

Smithsonian Institution
  Science Information Exchange

Library of Congress
  National Referral Center for Science and Technology

Activity Services[1]

During the past several years the National Science Foundation has obtained data from the Federal agencies concerning the services which are now performed in the dissemination of

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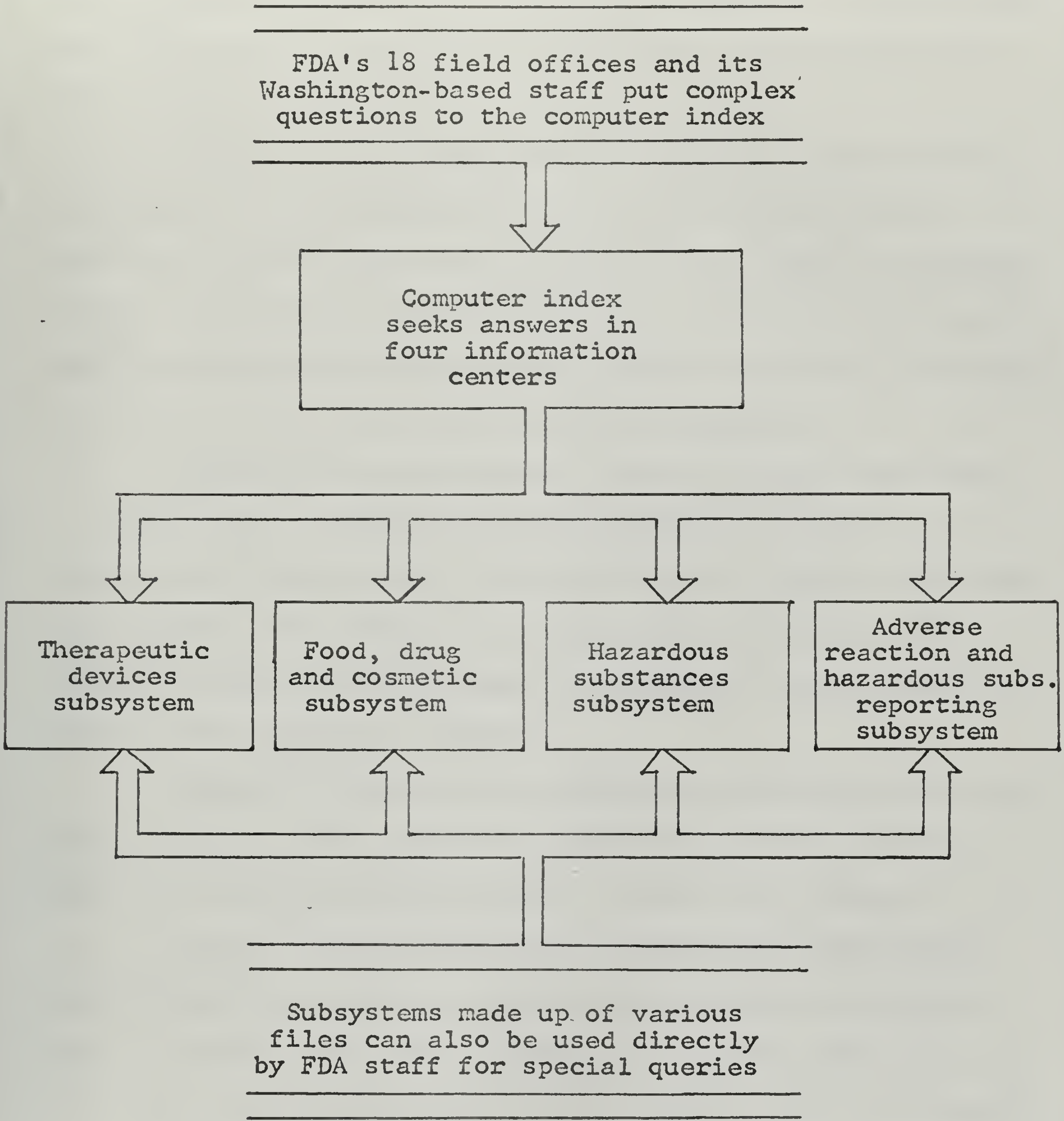
[1]The material contained in this section is taken from the National Science Foundation annual publication, Federal Funds for Research, Development, and Other Scientific Activities, Vol. XII, op. cit., pp. 69-72.

Figure 5.--Food and Drug Administration Scientific Data System[a]



[a]Source: "FDA Revamping Its Scientific Data System," Chemical and Engineering News, XLII, No. 37 (September 14, 1964), p. 32.

scientific information. These may be referred to as: (1) publication and distribution; (2) bibliographic and reference services; (3) scientific symposia and technical meetings; and (4) research and development in scientific and technical communication and documentation.

Publication and distribution activities, which include distribution of new scientific and technical information, represent approximately forty per cent of the total information outlay. Approximately $77.6 million was spent in 1964 for this purpose, of which the Department of Defense and the Patent Office spent $23.3 million and $20.7 million respectively.

Bibliographic and reference services provide the means to assist users in obtaining and exploiting available information. Approximately $80.2 million was spent in 1964 for this purpose. This service is principally available at the various libraries of the Federal Government, a major part of which is the Library of Congress.

Scientific symposia and technical meetings amounted to $23.4 million in 1964 and were principally supported by the Departments of Defense and Health, Education and Welfare.

Research and development in scientific communication, and documentation includes research on computer uses in this field, as well as language, indexing and service problems. In 1964 these expenditures reached $20.1 million, with the departments of Defense and Health, Education, and Welfare, and the National Science Foundation leading the Federal Government in this important activity.

Interagency Coordination

A study in 1962 concluded that there is "no coordinated, Government-wide policy for the dissemination of scientific information."[1] The Crawford Report noted that there was no formal agreement concerning subject coverage between the three National Libraries (Medicine, Agriculture, and Library of Congress). The prevention of duplicating information collection was left to informal arrangements. Lawrence Q. Mumford, Librarian of the Library of Congress, in testimony before the Humphrey Subcommittee, six months after the Crawford Report was published, confessed that a formal agreement was still in the proposal stage.[2]

Senator Humphrey also uncovered the absence of a formal system of information exchange between the National Institutes of Health and the Food and Drug Administration[3] despite the thalidomide tragedy of 1962 which pointed up precisely the need for such an exchange.

The communication problem between agencies has improved considerably during the past few years under the prodding of several Congressional Committees, the Bureau of the Budget, and the President's Science Advisors. Lately, departments and agencies have begun cooperating in this matter. For example, The Defense Department now has a policy whereby unclassified reports generated internally are made available to the general

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[1]The Humphrey Hearings, op. cit., p. 12.

[2]Ibid., p. 150. [3]Ibid., p. 124.

public through the Commerce Department bulletin, U.S. Government Research Reports, which is widely-read throughout the scientific community.

The inadequacy of scientific information dissemination has prompted many plans for its solution. Perhaps the best reasons for improving the system can be: better management, greater efficiency, direct financial savings, better utilization of highly-trained manpower. But another equally important reason has been suggested by Dr. Julius N. Cahn, of the Senate Subcommittee on Reorganization and International Organizations, who reasoned that:

> . . . enemies of the Republic are determined to use our "pool" of information for the detriment of this Nation; we can hardly afford to ignore their diligent use or to under-organize or under-utilize our own information.[1]

In the following chapter, some of the recommendations which have been introduced to help alleviate the information problem will be detailed. All have in common the need for governmental assistance; they pose monumental management problems.

Recent Trends

The Federal Government is slightly changing its emphasis by showing how scientific and technical information developed by agencies can contribute to industry. The budget request currently before Congress: (1) calls to attention the National

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[1] Julius N. Cahn, A System of Information Systems, A Report to the Fourth Institute on Information Storage and Retrieval, American University, School of Government and Public Administration, Washington, D. C., February 12, 1962, mimeographed, p. 2.

Standard Reference Data System for evaluating scientific data and the Federal clearinghouse for distributing technical documents resulting from government research and development which is being expanded within the National Bureau of Standards; and (2) advises that new legislation will be proposed to encourage the establishment of technical information centers through matching grants to states.[1]

A revealing statement is included in Special Analysis H entitled "Federal Research, Development, and Related Programs."[2] The improvement programs in scientific information handling are going forth at all levels of the government:

> The Committee on Scientific and Technical Information of the Federal Council for Science and Technology is stimulating the various agencies to strengthen their programs for handling scientific and technical information. The Committee has identified a number of problem areas in scientific and technical information handling and has appointed task forces to work on these problems with the objective of obtaining more effective management of existing programs and improving agency coordination. Problems under study include language compatibility in mechanized storage and retrieval, development of a single Government depository library system, technical vocabulary compatibility, development of descriptive cataloging standards, and research and development in information science.
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> In 1966 the largest expenditures will continue to be for publication and distribution of documents and bibliographic and reference activities with small increases provided over the previous year to reflect the continuing growth of published scientific and technical materials and the expansion of agency informational services. Of vital significance to the improvement of scientific and

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[1] U.S., Executive Office of the President, The Budget of the United States Government For the Fiscal Year Ending June 30, 1966 (Washington: U.S. Government Printing Office, 1965), p. 101.

[2] Ibid., pp. 443-61.

technical information systems is the investment in research and development. The present level of expenditure in research and development in information sciences, documentation, information systems, techniques and devices is approximately $50 million. A modest increase in such research and development is planned for 1966 to advance this effort and to initiate new projects.[1]

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[1] *Ibid*., pp. 459-60.

CHAPTER III

THE ESTABLISHMENT OF A FEDERAL INFORMATION CENTER

> A people may be unprepared for good institutions; but to kindle a desire for them is a necessary part of the preparation. To recommend and advocate a particular institution or form of government, and set its advantages in the strongest light, is one of the modes . . . of educating the mind of the nation not only for accepting or claiming, but also for working, the institution.
>
> John Stuart Mill[1]

Introduction

A variety of concepts concerning the best method of organizing to handle scientific and technical information exist today. Disagreement between, and even among, legislators, administrators, information scientists, and most important, the users, has delayed any real decision so far. Several plans and ideas have been offered, but none have gained any general acceptance. This chapter will cover the plans which appear most in the literature.

The concept of the central government's role in information handling extends from laissez faire to complete control. In terms of ascending government participation the concepts can

[1] John Stuart Mill, Considerations on Representative Government /1861/ (Chicago: Henry Regnery Company, 1962) Gateway Edition, pp. 11-12.

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be stated as: (1) the continuation of the status quo; (2) the federally subsidized and guided system; (3) the centralized federal agency system; (4) the centralized national clearinghouse system; and (5) the centralized national or international information system.

These ideas represent a spectrum of how much scientific communication is actually necessary. In a 1963 report of the President's Science Advisory Committee, the crux of the controversy was stated in this way:

> Since there are no unequivocal criteria for deciding what is a sufficient information system, why should one decide to spend more on communication, especially if it means spending less on something else or if one's efforts are useful mainly to someone else? How does the Head of a Federal agency decide the appropriate size of his information service? How does a professional society through its publication committee decide on a new journal? For that matter, how does a working scientist decide to spend more time in the library?[1]

The report goes on to show that the mere existence of a sophisticated information center does not guarantee its success. The attitudes of scientists and engineers must be recognized.

> It is not certain how scientists would react to the establishment of such a [centralized] system, since all previous experiments . . . have lacked some features essential to a successful central depository: adequate coverage; broadcast announcement; auxiliary select journals and retrieval services; adequate financial support; approbation by scientific and governmental leadership.[2]

One of the most articulate spokesmen for the establishment of a national science information center is Dr. Eugene Garfield who is Director of the Institute for Scientific

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[1]The Weinberg Report, op. cit., p. 9.

[2]Ibid., p. 31.

Information in Philadelphia and a lecturer in Information Retrieval at the University of Pennsylvania. At the Pucinski Hearings he hypothesized the results of handling telephone service as our scientific and technical communication is actually handled today.

> Imagine the chaos in the telephone company information centers if one day every other page in everyone's phone book were "unlisted" . . . . [Or] if there were hundreds of different phone books--some arranged by people's national origins, other by occupations, by district or by name--yet none of them complete. . . . Suppose each of these phone books, large and small, is only half complete and at least a year old when it arrives. Suppose that phone books were not free but cost so much that only libraries could purchase them.[1]

Dr. Garfield is one of many thoughtful people who have had the vision of a nationalized information center. In 1956, before many in and out of the Federal Government became alarmed over our shortcomings in scientific communication, Dr. Garfield urged the creation of a Central Intelligence Agency for Science.[2]

The objections to any plan for centralization cover one persistent theme: The Federal Government would create a bureaucratic logjam of information. In a recent issue of the scientific weekly, Chemical and Engineering News, it was reported that:

> Some scientists and scientific information specialists fear the system might lead to some sort of scientific control over the scientific literature and perhaps to the eventual elimination of the scientific journal.[3]

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[1]The Pucinski Hearings, op. cit., p. 227.

[2]Ibid., p. 237.

[3]"Science Library System Gets Mixed Reactions," Chemical and Engineering News, XLII, No. 24 (June 15, 1964), p. 22.

Calvin Mooers considers any plan for a national research library as a national bottleneck and suggests an alternative:

> A national cooperative library would be far more desirable and could include the many kinds of local documentary material in paper form which would never be copied and transmitted. . . . [It] would maintain them at their original locations and make generally available notice of where they are.[1]

Many choices are available in handling of scientific information on a national scale. Dr. Julius Cahn has stated that the Nation must have a plan which requires the efforts and cooperation of a vast number of individuals responsible for information offices, libraries, centers, systems, and services.

> The decision to move ahead with all proper dispatch toward a National Information Goal cannot be made by only one source, even the President of the United States, alone.
>
> It can be made--and be implemented--by the scientists and engineers of the Nation, acting--voluntarily--through their chosen instruments.[2]

In weighing the possible with the practical, one comes to the realization that the national or international clearinghouse concepts are not yet attainable. This represents an acceptance of reality. However, it is altogether possible and probable that, before the end of this decade, these ideas will be well within the range of practicality. John Pfeiffer, in an article in _Fortune_, believes that "a new public utility is in the making, an information utility that will make logic available at established rates to subscribers throughout the world . . ."[3]

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[1] _Management and the Computer of the Future_, ed. Martin Greenberger (New York: John Wiley and Sons, Inc., 1962), pp. 174-5.

[2] Cahn, _op. cit._, p. 22.

[3] John Pfeiffer, "Machines That Man Can Talk With," _Fortune_, LXIX, No. 5 (May 1964), p. 198.

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Watson Davis, Director of Science Service, a documentation firm, goes even further. He foresees the organization of "one big library," "one big journal," and a "world brain,"[1] which would permit instant communication around the world at any time.

The proposals to retain the present system or for the Federal Government to subsidize existing systems represent an approval of and resignation to the admitted information problem and therefore should be rejected as unsatisfactory. This leaves the centralized federal agency system as a compromise between inaction and impracticality. This system is considered to be an intermediate objective. The more difficult national and international systems will be kept as long-range goals and can be implemented as technology advances.

The selection of this alternative must be defended, examined, and appraised in the light of optimum resource utilization and specification of performance evaluation criteria. This will be accomplished by examination of the many proposals which have been contained in various publications, comparison with the needs of the users, measurement of costs, and consideration of operations problems. The approach will enable a spotlight to be placed on the recommended end-product and an examination to be made of several alternatives.

Just what is meant by a Centralized Federal Agency Information System? For the purpose of this paper, it is conceived of as a system which ties together the diverse scientific information activities of the Federal Government

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[1] The Pucinski Hearings, op. cit., p. 196.

through communications links. The system does not encompass the concept of one huge building which would contain all these activities. It is generally accepted that a "one roof" concept is not only technically infeasible but is patently impossible in our free society.

Solution Parameters and Organizational Restraints

Several questions immediately become important when considering restraints on solution of the information problem. There are very good reasons why a national center is not now in existence. Primarily it has been a matter of cost. In a study made for the Library of Congress, it was reported that it would take $31.6 million alone to completely computerize its system.[1]

Local libraries and small information centers have been able to attack only the fringes of the problem due to the costs involved; universities have only partially met the challenge. The pace of research into basic information science must compete with other items on crowded budgets. The net result is that the financing of university research has been left to the abstracting services and the Federal Government. It may be another indication of the times, but it cannot be disputed that everyone is waiting for the Federal Government to act. This, then, is a real restraint: No action will be taken unless Government acts.

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[1]Gilbert W. King *et al.*, *Automation and the Library of Congress*, A Survey Sponsored by the Council on Library Resources, Inc. (Washington: U.S. Government Printing Office, 1963), p. 32. John McCarthy, an Associate Professor of Communications Sciences at M.I.T., has estimated the total conversion cost at $2 billion in *Management and the Computer of the Future*, *op. cit.*, p. 171.

Other problems to be considered are: (1) the problem of standardization; (2) the relation of a new center to existing services; and (3) the question of the range of services to be offered.

Standards

The lack of standards is, to a degree, typical of a burgeoning discipline. But just as each science and management method have developed standards, so also must information science.

The Warren Study lists two types of standards problems which require consideration: (1) equipment and program format standards; and (2) glossary and thesauri development standards.[1]

The first type is analogous to the standardizing of weights and measures. Dr. Warren suggests that an engineering evaluation would be able to arrive at a workable solution to facilitate the physical transfer of information in a network.

The second type, which calls for "intellectual manipulation of inputs and outputs,"[2] is less susceptible to standardization. It, therefore, calls for experimentation over a lengthy period of time which, Dr. Warren hypothesizes, may take at least a decade.

Hattie Anderson, in Information Retrieval Management, has summarized the precaution in this way:

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[1]U.S., The White House, Office of the Special Assistant to the President for Mental Retardation, Proposal: The National Library of Science System and Network For the Published Scientific Literature, May 1964 (mimeographed), p. 17. Cited hereafter as the Warren Study after Dr. Stafford Warren, Chairman and Special Assistant to the President for Mental Retardation.

[2]Ibid.

> Documentation is a young art. For the past ten or so years, we have been preoccupied with the development of new techniques, few, if any, of which have yet proven themselves to the exclusion of others. Now, with small chance of consensus as to the best approach for a single situation, talk of compatibility emerges with standardization looming as its ultimate manifestation. Premature standardization on a large scale to systems which are not the best is entirely possible.[1]

Relation to Existing Services

There is a multimillion dollar business now engaged in information activities. Services are performed by existing centers, original content journals, abstract and index journals, papers and books. None of the service activities are particularly interested in being overwhelmed by a huge governmental network. Thus, some means of reconciliation must be offered to the industries which are being threatened. None of the proponents advocate the abolition of valuable services because of their diversity and the prohibitive expense which would be needed to duplicate them. Dr. Warren's recommendation in this regard is very sound and should be followed:

> 1. Research reports would be handled outside the proposed system by another government agency.
>
> 2. The contents of journals (both original and abstract) would be incorporated in the system but would continue to be published for their value to the scientist's penchant for serendipity. The scientist would always need to retain the browsing habits of old because of the very non-directional ways in which scientific insight is gained.[2]

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[1]"Compatability of Information and Data Systems Within A Company," Information Retrieval Management, op. cit., Ch. 14, p. 116.

[2]The Warren Study, op. cit., p. 25.

Range of Services

This problem, in many ways, is the most acute problem of all. Accordingly it must be decided early in the planning phase just how much service and in what sciences will the system operate. John C. Costello, Jr., of the Battelle Memorial Institute in Ohio, has said:

> Certain sciences or technologies may be represented by so few potential users in the organization, and the literature in which they are interested may be so large and complex, that effective coverage and service would be excessively costly. . . . Therefore, the areas selected should be those for which the system can hope to provide broad coverage with maximum anticipated benefit or return.[1]

Early Planning

Several considerations concerning centralization are logically disposed of early. Other considerations are best handled after these basic points are adequately covered. They are:

1. Objectives of the contemplated organization.
2. The best location in the Federal Government structure to fulfill objectives.
3. Changes which will be needed in existing government organization.
4. The gains that are anticipated to be gained from such a system.

Objectives

In Principles of Management, Professors Koontz and O'Donnell have referred to objectives as: "the goal of the firm. . . . ordinarily subject to simple statement and . . .

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[1]John C. Costello, Jr., "The Charter: A 'Must' for Effective Information System, Planning and Design," Journal of Chemical Documentation, IV, No. 1 (January 1964), p. 14.

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essential to the proper planning, organizing, staffing, directing, and controlling of any enterprise or any part of it . . ."[1]

Thus, the simple statement of objectives of a Federal information system is: To stimulate the communication of the Federal Government's scientific and technical information through improved management methods.

Several sub-objectives which become apparent are:

1. To unify responsibility for direction and review of the Federal programs and activities for the communication of scientific and technical information through planning, guiding, setting criteria, reviewing, managing, and improving all governmental activities involved.

2. To establish responsibility for high-level direction of information activities and cooperation with the proposed organization.

3. To take the lead in establishing standards in indexing and abstracting services, promoting research in improvement of documentation techniques.

4. To establish working communication with the scientific and technical communities of industry, the universities and colleges, and their foreign counterparts.

Location in the Federal Government

There are many arguments on the precise location of the proposed system. A listing of the various proposals and possible locations reveals the range of alternatives:

1. Expand the new clearinghouse of the Department of Commerce.

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[1]Harold Koontz and Cyril O'Donnell, Principles of Management: An Analysis of Managerial Functions (New York: McGraw-Hill Book Company, 1955), p. 430.

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2. Expand the National Library of Medicine now under the sponsorship of the Public Health Service.

3. Expand the Office of Science Information Services of the National Science Foundation.

4. Establish a new Bureau of Technical Resources as an independent agency of the Executive Branch.

5. Establish a new Cabinet-level Department of Science and Technology which would have scientific information as an important function.

The principle objection to each of the first two proposals was best stated in the Crawford Report which brought out the fact that the Commerce and Health, Education and Welfare Departments have their own research and development missions which would conflict with the larger mission of the proposed system. The danger is principally one of having the information activity swallowed up in huge existing department structures. The major point in favor of locating in either agency would, in Dr. Stafford Warren's opinion, capitalize upon existing organizations to forego the growing pains of a new organization and to take advantage of experienced staffs.

As stated earlier, the National Science Foundation already has the <u>legal</u> backing for establishing a Federal system. However, many have wondered at the wisdom of making this advisory staff-type organization get deeply involved in a large operation of this nature. The Crawford Report has noted that the National Science Foundation ". . . <u>supports</u> operations through contracts, grants and transfers of funds."[1] Together with their basic

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[1]The Crawford Report, <u>op. cit.</u>, p. 54.

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reluctance to do more, it is questionable whether it is suitable for the proposed system.

The fourth proposal--a new Executive agency--has been recommended in the Crawford Report as the best place for meeting the objectives of improved scientific communication. The principle reason is that a high-level bureau would be able to cut across the entire governmental organization and to communicate more effectively with those outside the government. The best reason for not adopting such a proposal is that the Executive Branch has too many separate organizations already and needs fewer, not more. This problem has been argued for years and should not be ignored.[1]

Finally, the Department concept has been an issue for years. Without going into the other functions which a Department of Science and Technology would perform, it is evident that scientific information would be an integral part. The major objections to the other proposals would be overcome: no previous committments, firm operational responsibility, departmental guidance, importance within department. The proposed Department would naturally assume many research and development responsibilities now scattered throughout the Government and would be able to obtain the services of many experienced persons from various Departments. Another reason in favor of this location is

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[1]Schuyler C. Wallace, in Federal Departmentalization: A Critique of Theories of Organization (New York: Columbia University Press, 1941) p. 152, quotes the 1937 Report of the President's Committee on Administrative Management as viewing the tendency of the federal administration toward "grotesque agglomeration of independent and irresponsible units, bogged by the weight and confusion of the whole crazy structure."

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that a flexibility and ability for growth would be insured; such growth would be discouraged if the information activity were directly under the President.[1]

The Weinberg Report is explicit in condemning such a proposal.

> Whether bringing the Government's total information system under a single organizational roof would improve communication is in the first place conjectural; in any case, even if the desired improvement were thereby achieved, better management of research and development would not automatically follow.[2]

Such a stand cannot be refuted. However there is no serious plan which envisages "a single organizational roof." Objections of this sort have served to confuse many realistic proposals. The following section will show what has really been proposed.

Existing Organizations

Several agencies, as noted earlier, already have broad legal powers in the scientific information area. Their relation to a new information bureau must be considered early in the planning stage so that enacting legislation also includes consideration of conflicting mandates. Being sound management policy in general, some method of reconciling the programs of the National Science Foundation, the Commerce Department, the

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[1] These proposals represent a cross-section of the choices available as to location within the Federal Government. No one proposal is clearly superior to any other. Thus, although the writer favors a new department for the function, success could be gained under almost any of the proposals.

[2] The Weinberg Report, op. cit., pp. 10-11.

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[1] [illegible]

[2] [illegible] pp. 70-71.

National Libraries, the Smithsonian's Science Information Exchange, and the Defense Documentation Center, must be made.

Admittedly the majority of department-oriented organizations must stay within the structure of their departments because of the absolute need to keep specialized information close to the departmental user. Other activities are not so closely associated with their parent departments. The Office of Science Information Service of the National Science Foundation, the clearinghouse of Commerce, even the National Libraries are more attuned to centralized leadership. But the age-old problem of resistance to change, especially when it is viewed as unnecessary change, is real. Loss of prerogatives, uncertainty, necessity of re-establishing organizational relationships are principle problems to be faced. Early consideration of possible implications of a change will help to dispel this resistance. Professors Koontz and O'Donnell have observed that: "When morale is damaged by reorganization, the fault may be ascribed to a lack of facts and understanding as to the need for the reorganization, an ill-conceived organization plan, or a staff of poorly qualified executives."[1]

Dr. Garfield has cited, as an example, the fears held by many librarians when the Library of Congress began a centralized cataloging system. Since then the small library has benefitted greatly by relief from this burden obtained through centralization.[2]

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[1]Koontz and O'Donnell, op. cit., p. 285.

[2]The Pucinski Hearings, op. cit., p. 248.

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Anticipated Gains

It is not enough to state that centralization will "improve" scientific communication. Vague promises of potential savings often neglect the nature of humans. Perhaps the estimates that ten or more per cent of the annual federal research and development budget could be saved are true. Since this represents more than one billion dollars, can it be assumed that an improved system will save that much? The answer is that it will probably not, due to the unmeasurability of such savings.

While needless duplication of scientific research must be avoided, the problem is not easily solved because not all duplication is actually needless. Norman T. Ball has observed that: "when the objective is important and the solution difficult . . . parallel endeavor by different groups may be the only reasonable hope for an early and superior solution."[1] Thus elimination of duplication cannot be a sole improvement objective.

Elimination of some coverage duplication and the filling in of uncovered areas of information services is perhaps a better objective and more compatible with a centralized system. Mr. Joshua Stern, of the Senate Subcommittee on Reorganization and International Organizations agrees with this observation and further believes that "the potential enhancement of the rate of progress of research is of far greater import in the race for

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[1]"Duplication of Effort, Research and Development Programs," Scientific Research: Its Administration and Organization, ed. George P. Bush and Lowell H. Hattery (Washington: The American University Press, 1950), Ch. 19, p. 128.

technological superiority on which our national security depends."[1]

In a letter to Senator Humphrey, Gerhard P. Schuck-Koblen, head of information services of a coal company, cited four gains which would be necessary. Although he is in favor of a national, rather than a Federal system, his observations are relevant.

> Such a national center would be worthy of consideration, but it would have to satisfy several requirements:
>
> 1. It should be capable to process all this information, without any gaps. It would be insufficient to limit the collection only to federally-supported research.
>
> 2. The material should be selected with great care to eliminate any duplication of information and repetition of known art.
>
> 3. Information should be available immediately upon request by mail, or even by telephone.
>
> 4. The system must contain facilities to eliminate information as it becomes obsolete.[2]

The prospect of the government being able to abstract a research report just once, of making its existence known to more potential users, and then in making the report widely available has tremendous implications in terms of savings of not only money, but also manpower and other resources. A 1963 survey sponsored by the Library of Congress reported that:

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[1]U.S., Senate, Committee on Government Operations, Coordination of Information on Current Research and Development Projects in the Field of Electronics, Committee Print, 87th Cong., 1st Sess., 1961, p. xxxv.

[2]Letter from Gerhard P. Schuck-Koblen, Consolidation Coal Company, to Senator Hubert H. Humphrey, March 22, 1962. Quoted in entirety in Exhibit 23 to the Humphrey Hearings, op. cit., p. 214.

. . . numerous specialized documentation centers have been established in industrial organizations. The cost of this, in duplicated acquisitions alone, is very high, and the effect on intellectual activities may be profound.[1]

Plans of Action

At this point the question of details becomes more apparent. If a change is desirable, how will it be accomplished? The Crawford Report and Warren Study have been referred to throughout this study because they fitted the systems concepts being used. The Crawford Report, and to a lesser extent, the Warren Study, both develop their plans of action in more detail than is desirable in this management approach to the scientific information program. However, these plans do serve to bring together many of the factors which have been covered thus far and to introduce the final points concerning users, personnel, mechanization, and costs. It is to be emphasized, however, that the plans are presented to demonstrate the complexity which is involved and not to recommend the details of the plans.

The Crawford task force used the relatively new PERT method to develop an implementation plan.[2] As shown in Figure 6, the plan calls for four phases of action. The first two phases can be completed without new legislation; the latter two cannot. Each item is completed in order from 1 to 36. The major objectives of the plan are encircled. The arrows represent

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[1] King etal., op. cit., p. 5.

[2] PERT, or Program Evaluation Review Technique, was developed by the U.S. Navy for the Polaris submarine program. It is a management tool which introduces the time factor to project planning and execution.

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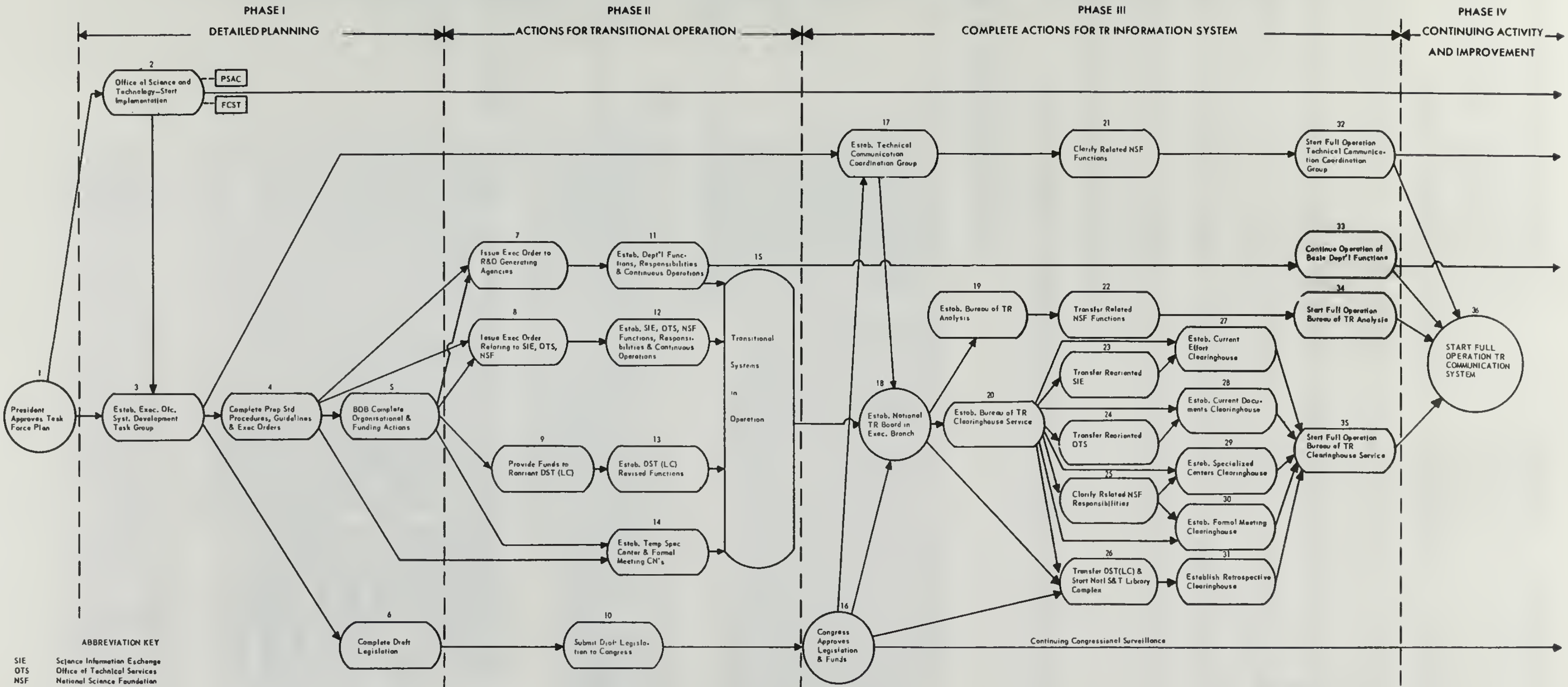
FIGURE 6 **PLAN FOR IMPLEMENTATION OF TASK FORCE RECOMMENDATIONS**[a]



ABBREVIATION KEY

SIE	Science Information Exchange	BOB	Bureau of the Budget
OTS	Office of Technical Services	PSAC	President's Science Advisory Council
NSF	National Science Foundation	FCST	Federal Council for Science & Technology
CH	Clearinghouse		
DST(LC)	Division of Science and Technology (Library of Congress)		
TR	Technical Resources		
S&T	Science & Technology		
R&D	Research & Development		

[a]Source: Scientific and Technological Communication in the Government, a Task Force Report to the President's Special Assistant for Science and Technology, James H. Crawford, Jr., Chairman (Washington: 1962), p. 59.

the interdependency of events but do not represent specific lengths of time.

The Warren Study has proposed a gradual system on a national basis. The plan proposes to limit the content of the system to open published scientific literature--the scientific journals. Dr. Warren defends this recommendation because of the stability and clear definition of this type literature. As experience is gained it is expected that reports and classified literature be included.

Dr. Warren recommends a five-step plan in carrying out his recommendation:

> 1. Identify holdings and acquisition programs of the major Federal libraries and professional associations, and by agreement assign to each Federal library, or other participant, a portion of the list of published scientific publications which each would contribute to the pool or system in the form of tapes or microform, produced under acceptable standards.
>
> 2. Foster agreement between the Federal and private sectors on standards and for compatible procedures for the acquisition, analysis and coding of scientific articles in the various disciplines.
>
> 3. Work toward the ultimate goal of a complete storehouse on tapes of published periodical literature (summaries, abstracts and citations) which would be fed continuously by existing programs in the Federal and private sectors, and augmented in areas not covered adequately. This storehouse would . . . stock a network of regional centers, . . . [which] would serve as distribution points . . . [for] the libraries of organizations throughout the nation.
>
> 4. Foster development in universities of curricula for the education of librarians and information scientists who would staff the operating units of the [system].

5. Foster development of basic research in the library and information sciences, including semantics, linguistics, philosophy, logic, mathematics and statistics and other disciplines bearing on the field.[1]

To conduct the operation and management, the Warren Study recommends that in place of a new agency or commission or the addition of the responsibility to the Library of Congress, the National Library of Medicine be given primary responsibility in operation of the system. Existing libraries would be continued in their present organizations and would coordinate, as stated above, through an Advisory Committee on operations. The membership of this committee would be drawn from the principle participants in the system.

Figure 7 is a representation of the information flow in the operation of the primary center. Each sattelite library would have both input and output with the center. The centers would communicate with each other and with users.

Such a plan, of course, calls for cooperation with professional societies and editors of scientific journals. Dr. Warren proposes that cooperation be developed in preparation of abstracts (by the author himself if possible) and of glossaries covering the disciplinary interests of each journal and participation in processing and analysis activities. Since these organizations would probably reject any potential threat to their continued existence Dr. Warren observes that even though material is available in the system "great advantages accrue to the scholar and the student by browsing among the journals in the stacks and library shelves."[2]

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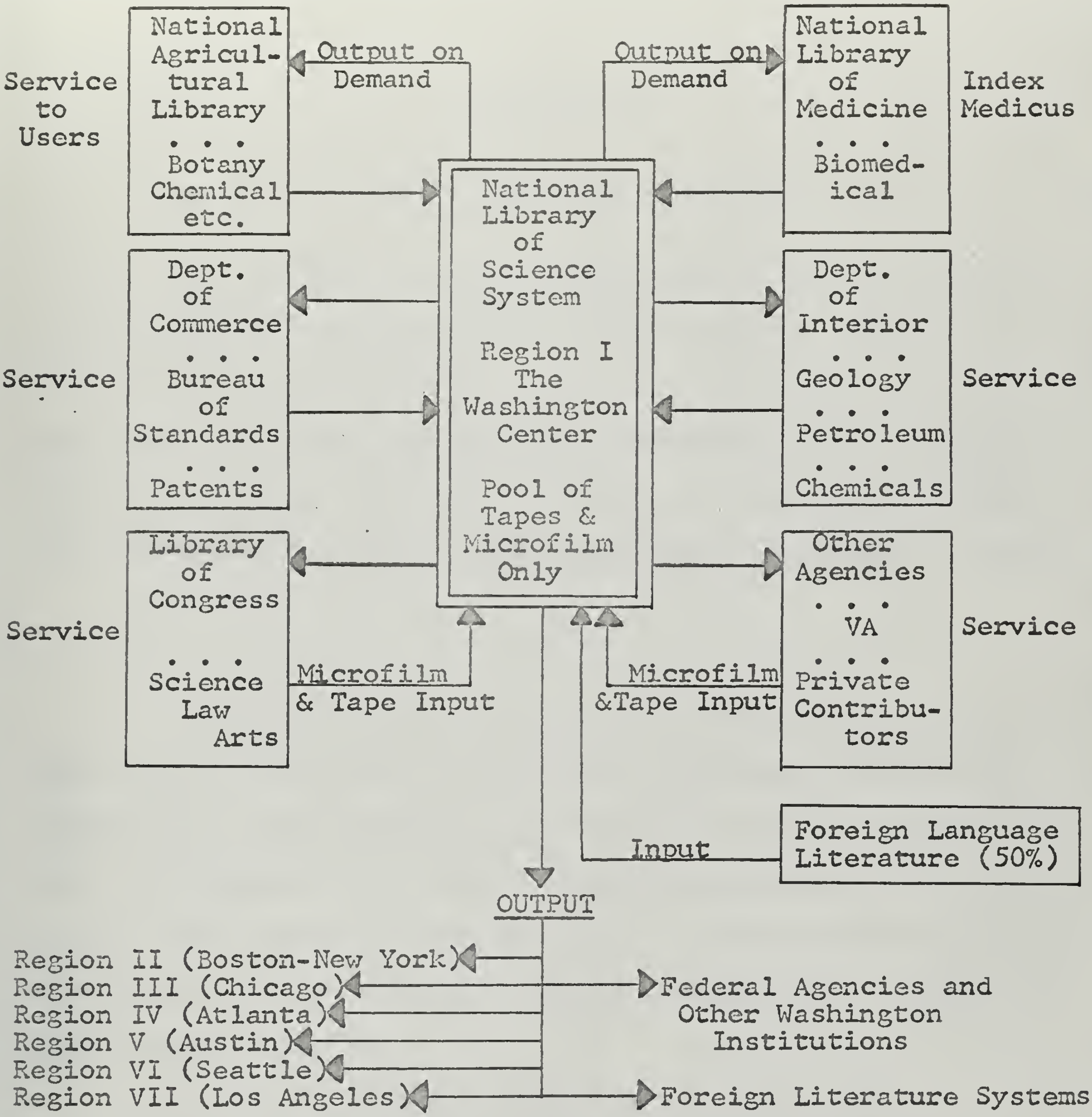
[1]The Warren Study, op. cit., pp. 5-6. [2]Ibid., p. 25.

Figure 7.--Information Flow. Input and Output Examples of Operations of Regional Center[a]



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[a]Source: U.S., The White House, Office of the Special Assistant to the President for Mental Retardation, Proposal: The National Library of Science System and Network for the Published Scientific Literature, May 1964 (mimeographed), p. 14.

CHAPTER IV

OPERATIONAL CONSIDERATIONS

Four important considerations must also be taken into account in developing a system of this nature. Simply it is the problem of who does what, with what resources, for whom, and for how much. These are the user, personnel, mechanization and cost factors. Each will be taken in order and be fitted into the general scheme of the recommended information system.

Users

The most important side of the information triangle must always be the user. The administrator and provider of information are essential, but they must take the position that the system must fit the user and not the reverse. Information is not being stored for its own sake. It must be channeled to users in an efficient manner. Helen Brownson, in reporting on this subject observed:

> . . . study of the information requirements of scientists is difficult, for the communication of scientific information is extremely complex. Needs vary with the subject field, the type of research, the availability of information services and source materials, geographical situation, and differences in human abilities. In fact, the needs of a single individual may vary from time to time, depending on his current interests and activities. Furthermore, the real

> needs of scientists and their conscious or expressed needs may be quite different.[1]

To this end, John Costello insisted that "members of the user group should be involved in preoperational phases."[2] Such a procedure will not only facilitate the transition phase, but will give greater identification to the system by the user. This merely attacks one of the major problems at the source. The scientist--or any one else--becomes suspicious of someone who is trying too hard to help.

Another point in favor of developing the assistance of the user was stated by Simon Newman, a documentation consultant who has been involved in the field for over thirty years:

> . . . no user, no matter how sophisticated he may be, asks the question to which he wants an answer; instead, he asks the question he thinks the system can answer.[3]

To have a truly useful system information must not only flow to the user; it must flow from the user and into the stream of scientific thought.

Aside from getting the scientist to appreciate his information source more there is the vexing problem of catering to the spectrum of needs. An experienced man will tend to ask different questions than the novice. Two equally experienced scientists will ask different questions, seek different methods,

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[1]"Documentation Needs of Scientists," Information Retrieval Management, op. cit., Ch. 10, p. 77.

[2]Costello, op. cit., p. 13.

[3]"Economic Justification-Factors Establishing System Costs," Information Retrieval Management, op. cit., Ch. 15, p. 119.

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arrive at different conclusions. Samuel Alexander, of the National Bureau of Standards, has also observed that the working scientist is often moving from one discipline to another, may be working at the frontier of his specialty, and is looking for specific information.[1]

The process does not stop once a specific question is answered. Dr. Y. S. Touloukian, a Purdue University thermophysicist, has observed that, in real situations, a series of questions and answers flow until the satisfactory question is asked and an answer received.[2]

A 1963 survey made for the Library of Congress reached the conclusion that:

> The library of the future should be one that actively participates by predicting the areas for which information will be needed and in minimizing the time the user must spend in ascertaining pertinence of library materials to his special interests.[3]

What can the scientist expect from the system? What restraints must be drawn to keep the system manageable?

Needs

Several of the more important needs of scientists are:

1. Current information about who is doing what.
2. Information on meetings.
3. Higher editorial standards for primary journals.
4. Access to government reports.
5. Access to patent literature.

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[1] The Pucinski Hearings, op. cit., p. 86.

[2] Ibid., p. 187.

[3] King etal., op. cit., p. 5.

6. Access to information on negative results, provided they are obtained under proper conditions.
7. A central source of reprints or photocopies of journal papers.
8. Better translation services.
9. A searching service.[1]

The list can be continued. But the mere listing brings to attention the problem of constraints, of asking so much of a system that its costs become prohibitive. Here the management of the system must establish priorities and exercise restraints. The best answer to the problem is for consultation with the users. They can best develop priorities on what they need.

In this regard, Watson Davis has made an incisive observation on this very human problem:

> Scientists are such modest and undemanding individuals that they overlook the possibility of utilizing the marvelous communication devices that science and technology have created. When a researcher is "hot" after an idea, he should search for the facts and information that he needs wherever they might be found. He should pick up the telephone and, if necessary, talk across the continent or across the oceans to the three or four colleagues who know what he is trying to do and who could possibly help him in his research.[2]

Personnel

If the user is the reason for the system at all, it remains for the user to be provided with information by others. These others, who have been identified in this section as "personnel," are known by many titles. The following list of

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[1]Brownson, Information Retrieval Management, op. cit., p. 78.

[2]The Pucinski Hearings, op. cit., p. 197.

some of these titles show the range of activities involved in information processing:

Technical Documents Supervisor
Technical Libraries Supervisor
Acquisition Specialist
Information Systems Engineer
Indexing and Vocabulary Specialist
Technical Information Specialist
Literature Scientist
Information Technologist

In addition to these newer titles the more familiar ones, such as librarian or researcher, are also used.

The problems of obtaining, training, and developing the manpower to staff a new information system of the scope envisioned runs into several limiting factors. Two of the more important are: (1) the need for duality of competence, and (2) the methods of training to be utilized. These two factors will be examined in the following sections.

Competence

The simple fact remains that scientists will not use a service if unqualified personnel are his link with it. Therefore it is essential to employ people who can understand the needs of, and can communicate with, the user.

The Warren Study contains the observation that:

> Professionals in this field are in very short supply, and only a few universities have yet established curricula which can provide competent specialists in sufficient numbers.[1]

The method of meeting this problem will, in a large way, determine the quality of the system. This raises an immediate question.

[1] The Warren Study, op. cit., p. 21.

Should personnel be science-trained, information-trained, or both, and in what order? It has been the experience of many that there is just no ready source of personnel of this type and in the necessary numbers graduating from our schools. Consequently professional standards have not yet developed. Dennis Puleston, Head of the Information Division of the Brookhaven National Laboratory, has written:

> It is a sad fact that at this time very few of the people who are filling these positions as best they can have been trained specially for this work. Some are scientists who have, generally from a sense of duty, abandoned their research to fill positions which had to be filled. . . . Others are librarians by training, who do not have the deep scientific background to comprehend fully the problems of the scientist seeking information. Others are administrators with no training in either science or librarianship.[1]

The question of competence in two or more specialties invariably leads to the question of compensation and the status of information activity as a profession as opposed to active research. Resolution of the problem is best attacked by educating and upgrading the information profession.

Training

The answer is not in training more or better librarians. Although this type of training is needed, it should not be confused with the active function which is required in scientific information systems. Dr. Eugene Garfield testified that as late as 1963 there were only "two institutions that have a program

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[1]Letter from Dennis Puleston, Brookhaven National Laboratory, to Senator Hubert H. Humphrey, March 30, 1962. Quoted in entirety in Exhibit 23 to the Humphrey Hearings, *op. cit.*, p. 216.

that begins to even approach the curriculum needed for information scientists."[1] He intimates that as long as these programs are associated with library training they will suffer. What is needed, Dr. Garfield concludes, is for major universities to ". . . establish an information science program which unites all the interdisciplinary facets of the problem--computers, linguistics, philosophy and mathematics, library science, communications, sociology, etc."[2]

In 1962 the President's top science advisor, Dr. Jerome Wiesner, put the solution of the problem in a clear light when he said that some of our best scientific talent must be encouraged.

> This will involve some diversion of scarce, high quality technical manpower to the information task; but it will greatly enhance the effectiveness of the entire scientific and engineering community.[3]

The process of education of the information scientist--and the user himself--is now a major stumbling block to the development of more and better information systems. The improvement will take time; but as Dennis Puleston wrote:

> With . . . a well-rounded background and training, the professional status, and the appropriate emoluments to go with it, I believe that the profession of Technical Information Specialist will be one sought after by many promising young persons with scientific leanings and abilities. Only in this way can our country hope to meet the heavy and

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[1]The Pucinski Hearings, op. cit., p. 230. These institutions--both in Philadelphia--are the University of Pennsylvania School of Electrical Engineering and the Drexel Institute of Technology.

[2]Ibid.

[3]The Humphrey Hearings, op. cit., p. 32.

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[1] [illegible]

[2] [illegible]

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> ever-growing demands of our national science and technology programs for the rapid and efficient communication of technical information.[1]

Mechanization

The introduction of computers into scientific information handling has been both a blessing and a curse. Too often those unfamiliar with the deep-rooted difficulties which have been encountered assume that the computer with its ability to store vast amounts of data is waiting on the shelf to be ordered. True, computers are available for certain applications. However, as Herbert A. Simon and Allen Newell, in writing of the relationship of management to computers in general, have observed:

> Pattern recognition, a crucial process in handling poorly structured problems and an essential element in flexible perception of a "raw" external environment is at present a major bottleneck in mechanization. It appears as a particularly serious difficulty in information retrieval systems, where pattern recognition generally turns out to be the most expensive part of the entire process. Pattern recognition is an active arena of fundamental and applied research but it is exceedingly difficult at this moment to assess what developments are most promising and what the timetable is likely to be.[2]

The problem then is not in retrieving information but in getting it adequately stored. This is the process of indexing, arranging, classifying, and coding. John R. Pierce

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[1] Dennis Puleston, op. cit., p. 216.

[2] "What Have Computers to Do With Management?" Management Organization and the Computer, ed. George P. Schultz and Thomas Whisler (Chicago: The Free Press of Glencoe, Ill., 1960), Part II, p. 60.

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has observed that ". . . information cannot be stored unless it is in machine-readible form."[1]

Of prime importance at the planning stage is restraint in regard to mechanization. Management must avoid the danger of selecting the wrong machinery for the wrong purpose.

John Costello has laid down four excellent principles regarding mechanization. To paraphrase, these principles are:

1. Select equipment only after a fundamental philosophical system has been selected.

2. Require a complete study of the economics of mechanization versus other means. The gains in service, speed, accuracy and efficiency must be clearly shown.

3. Require accurate cost data on the computer system. Study such non-computer, mechanical systems which utilize edge-notched cards, punched cards or optical-coincidence cards as either substitute or ancillary to a computer system.

4. Design the system to fulfill system objectives. Computer salesmen, systogrammers, and programmers have in many instances caused revisions be made to fit a certain computer system. The system should not stray from the specifications which were set up for the best possible service to the user.[2]

These important points underline the admonition which was contained in the Weinberg Report:

> Administrators and documentalists will have to improve their grasp of modern information-handling technology so that they do not look upon elaborate and expensive computers as magical panaceas for their information-handling woes.[3]

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[1]"What Computers Should Be Doing," Management and the Computer of the Future, op. cit., Ch. 8, p. 302.

[2]Costello, op. cit., pp. 18-19.

[3]The Weinberg Report, op. cit., p. 21.

The Future

Improvements are inevitable. Therefore any existing system must be able to adapt to new information handling techniques. One promising improvement has been suggested by Herbert A. Simon. Noting the bottleneck involved in converting existing books into computer-usable form, the logical solution would be to link magnetic tape to the linotype machine used to print the book originally. The congestion is by-passed and the text is available for retrieval of information, and not merely an index.[1] Once on tape, the information can be transposed, abstracted, indexed, and distributed.

The problem of storing vast amounts of textual material, we are told, is close to solution. In a recent article in *Fortune* concerning computers it was reported:

> There is also likely to be a sharp increase in the capacity of slower-access external memories, corresponding roughly to reference libraries; these contain tables, programs, and data that can be used when needed but are not filed in high-speed memory. Currently, a large external memory may contain 100 million bits or more, stored on magnetic tapes or on special devices consisting of metal disks, from which information can be extracted through pickup units like the playing arms of jukeboxes. A short-term objective is to increase this sort of memory to about a trillion bits, enough information to fill a thousand sets of the Encyclopedia Britannica. Some investigators are already looking beyond that to capacities 10,000 times greater, holding more information than is contained in all the world's libraries.[2]

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[1] *Management Organization and the Computer*, *op. cit.*, p. 64.

[2] Pfeiffer, *op. cit.*, p. 196.

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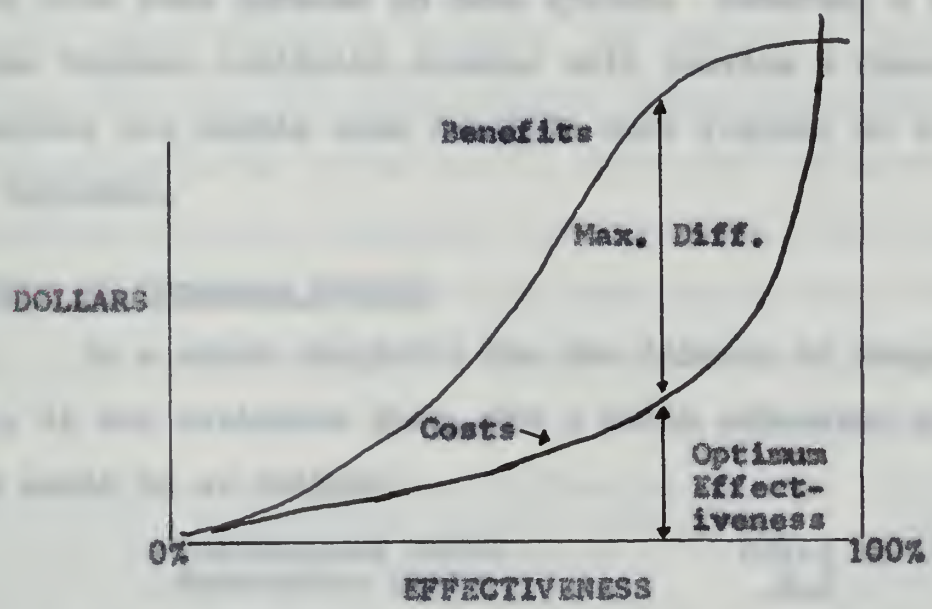
Costs

In regard to costs, Dr. Eugene Garfield has said:

> The average scientific report represents thousands of dollars of taxpayer money. The cost of making this information readily accessible is infinitesimal compared to its original cost, which is increasing simply because an insufficient percentage of budgeting is devoted to science information and communication. However, as with any other problem, once the problem is identified one must then consider the cost of the solution, if a solution is available, and who will pay for it.[1]

Inevitably the question of cost will determine the extent of the system. Benefits to be gained from the system must be matched against dollars. Figure 8 shows the "Economics of Retrieval" and measures effectiveness against cost.

Figure 8.--Economics of Retrieval[a]



[a]Source: U.S., Senate, Committee on Government Operations, Documentation, Indexing, and Retrieval of Scientific Information: A Study of Federal and Non-Federal Information Processing and Retrieval Programs, Document No. 113, 86th Cong., 2d Sess., June 23, 1960, p. 189.

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[1]The Pucinski Hearings, op. cit., p. 228.

Benefits rise more quickly than costs until a certain point. Then the benefit curve starts to flatten and the cost per unit of effectiveness rises quickly. The optimum point of cost effectiveness occurs when the benefits and costs curves are furthest apart.

Unfortunately, there is no objective way to measure effectiveness. The closest we can come now is to reckon present costs, estimate effectiveness, and estimate the cost of improving the system taking into account the economic considerations evident from Figure 8, above.

Several sets of cost figures are available with the reports previously mentioned. A meaningful comparison is not possible because of the parameters, limitations, and services which have been imposed on each system. However, a brief review of the various available studies will provide a frame of reference and enable some tangible cost factors to be examined and compared.

Library of Congress Report

In a study completed for the Library of Congress in 1963, it was estimated that, for a fully automated system, the cost would be as follows:

Procurement Costs	\$28.3 million
Conversion Costs	3.3
Total One Time Cost	\$31.6
Annual Operating Cost for a Typical Year	\$4.5[1]

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[1]King *et al.*, *op. cit.*, p. 32.

The study estimates that total obligations incurred between 1962 and 1972 will amount to $320.5 million without automation and $352.2 million with automation. Thus once the basic installation cost is paid for, the system costs no more than a manual system but is expected to improve service tremendously. However, the Library of Congress is only one library and its function is fairly well-defined. It would not perform the service expected of a Federal scientific information system.

Crawford Report

Although the Crawford group presented the most detailed conversion plan yet available, the report played down cost factors considerably. The aim of the system was to provide clearinghouse capabilities in five distinct areas: (1) planned and active research and development efforts; (2) results of research and development work; (3) retrospective search and retrieval services; (4) coordination of access to all Federally-supported information activities; and (5) scientific and technical meetings.[1]

Estimating that activity would expend over two to four years, the report summarized annual costs[2] as follows:

	Annual Increases
Government-wide direction and review	$ 150,000
Scientific information systems research	350,000
Agency-wide direction and control	1,500,000
Information operations in agencies	30,000,000
Information operations of contractors	20,000,000
Government-wide clearinghouse services	8,000,000
Total Estimated Increase in Level of Annual Support	$60,000,000

[1]The Crawford Report, op. cit., pp. 47-9. [2]Ibid., p. 55.

The Warren Study

The Warren group has provided a detailed budget for the first six years of its recommended system. Although the system envisaged covers only the published journal literature, its costs are not inconsiderable. Table 4 is a listing of these projected costs. The first three years are taken for organizing, planning, designing, conferring, pilot programming, and education and research programs, plus the construction of the first regional centers. The second three years represent the operational costs of the service, averaging slightly more than $60 million a year.

Simulation Techniques[1]

In discussing cost factors there comes a time when alternative methods must be chosen through some decision-making process. Computer simulation has been used increasingly in business by a program which "accepts detailed description of the operating performance, costs, and interrelationship of all components in a proposed system."[2] The system is projected over a several year period to enable computation of estimated operating costs, equipment requirements and costs, and personnel needed to operate the system. Bourne and Ford have shown the usefulness of the computer in integrating the many components and interrelationships which could not be considered without machine assistance.

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[1]This entire section is based on an article by C. P. Bourne and D. F. Ford, "Cost Analysis and Simulation Procedures for the Evaluation of Large Information Systems," American Documentation, XV, No. 2 (April 1964), pp. 142-49.

[2]Ibid., p. 142.

Table 4.--Warren Study. Tentative Budget for National Library of Science System[a]

(In $ Millions)

	1964-65	65-66	66-67	Total 3 yrs
Extramural Grants Education & Training	2.0	4.5	5.0	11.5
Research and Development (including pilot programs)	5.0	15.0	25.0	45.0
Conferences and Planning	2.0	2.5	1.5	6.0
Facilities Washington D.C. Center Planning	1.0	1.0		2.0
Regional Centers and Units		3.0	50.0	53.0
Operation		1.75	3.0	4.75
Total First 3 Years	10.0	27.75	84.5	122.25
	1967-68	68-69	69-70	Total 3 yrs
Extramural Grants	31.5	35.0	40.0	106.5
Facilities	35.0	25.0		50.0
Operation	8.0	10.0	12.0	30.0
Total Second 3 Years	64.5	70.0	52.0	186.5

[a]Source: U.S., The White House, Office of the Special Assistant to the President for Mental Retardation, Proposal: The National Library of Science System and Network for the Published Scientific Literature, May 1964 (mimeographed), p. 35.

In the example contained in the article, two systems are compared. The simulation procedure involves four steps:

1. Formal description of candidate system in which input time and cost data, interrelationships, and constants are stated.

2. Computation of estimated monthly operating costs.

3. Representation of monthly costs as a single cost figure.

4. Extension of the analysis to many different operating conditions.

It is the last step which provides interesting comparative cost data. The system example, for instance, compared differing inputs with a varying number of searches per month. The annual cost was obtained for each condition. Table 5 is a partial listing of the figures obtained from the simulation model. In this model it can be seen that the economies of scale hold up until the 1000/1000 Input/Volume rates are exceeded. This compares with the economics of retrieval graph shown on page 86.

Table 5.--Equivalent Uniform Annual Operating Costs[a]
(In $ thousands per year)

Input Rate	Search Volume (number of searches per month)					
	Alternative 1			Alternative 2		
(Items/Mo.)	1	1000	100000	1	1000	100000
1	188.4	188.6	347.4	167.6	168.2	413.7
1000	188.6	188.7	347.5	168.3	168.9	414.4
100000	379.6	379.8	557.9	303.3	304.0	550.6

[a]Source: C.P. Bourne and D.F. Ford, "Cost Analysis and Simulation Procedures for the Evaluation of Large Information Systems," American Documentation, XV, No. 2 (April 1964), p. 148.

The simulation method is not a computer room curiosity; it is useful and it has been tested in actual application. Such a management tool would be indispensable to the detailed planning phases of the Federal system and would aid immeasurably in selection of the best system at the most favorable cost.

Other Considerations

There comes a realization that in many ways costs cannot be measured. How can the commodity "knowledge" be subjected to a cost accounting? Will the scientist be likely to share credit with an information center after making an important discovery? It is not at all certain that he should; after all, it is still the creative ability of the scientist which leads to discovery.

Lowell Hattery has observed that: "Cost evaluation should take into account the penalties attached to lack of information as well as the values of the information program provided."[1] The difficulties of measuring costs was attacked from a slightly different standpoint by Simon M. Newman who questions cost accounting procedures because output cannot be computed.[2]

Controls

In order to provide the necessary service, on a limited budget, and to prevent unwanted expansion of service, the system must have a strict set of controls. Controls can permit collection of necessary statistical data for management evaluation of service, economics, and programs.

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[1] Information Retrieval Management, op. cit., Ch. 1, p. 14.

[2] Ibid., p. 117.

John Costello has listed some of the data which would be useful. Armed with the following information, management will be in a better position to control costs and operations:

1. Number of searches conducted.
2. Individuals and groups for which searches were conducted.
3. Search times required.
4. Volume of input.
5. Details of "peak and valley" effects in receipt and input of material.
6. Indexing times for documents by type.
7. Depth of indexing of individual documents by type.
8. Volume of material received by source.
9. Input lag time (the time which elapses between receipt of a document and its being accessible through the index.
10. Rejection rate by source and reasons (total number of documents)[1]

Quality control must also enter into consideration. A useful system will affect costs through better management.

> Screening standards for input and removal should be based on the premise that the system is designed to provide for recall and reuse of information, not merely to serve as a warehouse or mausoleum for all documents that have ever been written.[2]

In summary, it is possible to see that the way these four operational considerations are handled in inaugurating a Federal scientific information system will largely determine its success or failure. It is submitted that these factors are merely extensions of a well-planned system. If the systems approach has been strictly controlled, the proposed network will have a head start to success. The complexities of the entire operating system cannot be foreseen; but each pitfall which management can avoid will contribute to user satisfaction, staff morale, useful service, and efficient operation.

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[1]Costello, op. cit., p. 17. [2]Ibid.

CHAPTER V

SUMMARY AND CONCLUSIONS

The preceding pages have presented a variety of arguments both for and against the centralization of scientific information management. Several general conclusions can be reached on this problem on which there can be little dispute. These points are as follows:

1. There is a considerable amount of emotion concerning the division of responsibility among scientist, information provider, and manager. Emotion is caused by many factors such as professional suspicion and snobbery, misunderstanding, and misinterpretation of motives.

2. This misunderstanding is part of a larger problem which exists between science and government.

3. The involvement of the Federal Government in science and research and development will continue to be a major consideration in any move toward improvement of scientific communication.

4. Management of plans and operations is essential to continued support of any information activity. The inability to accurately measure the value of information makes it imperative that the service be well-organized, efficiently directed, and properly staffed.

5. Mechanization is an extremely important consideration but must not overshadow the other important management decisions concerning training, services, and costs.

These general comments state some universal truths about organization and management and serve to prove an important but not always remembered fact: Scientific information activity is as susceptible to management methods as any other organization. Failure to accept this fact has delayed the inevitable start toward its improvement.

The following recommendations are submitted as being practical yet progressive, possible yet advanced, beneficial yet affordable. Various suggestions have been mentioned in regard to the question of what services are to be performed. The Crawford task force recommended that virtually all scientific literature be included in a comprehensive network. Integration of all phases of science information--reports, books, meetings--is just too venturous for the state of the art of information retrieval at this time. The following plan takes the limitations of technology into account, strikes a balance between the visionary and the practical, and views the implementation procedures as the foundation for a progressive addition of newer functions to the system over a long period of time. Thus the systems approach, which has progressed from a statement of problems, now is at the stage where some solution proposals are to be formulated. Many of the ideas have been documented elsewhere in this paper and the literature of the field. The major difference between these recommendations is in the degree of centralization and the extent of the services which will be provided by the system.

The following steps are considered essential to the success of the proposed system.

1. Establish an organization within the Federal Government which would have a specific responsibility to integrate the Federal scientific communication program throughout whole government. The information agency would have the responsibility to start planning, research and development, and programming for the specific purpose of centralizing science information. Long-range plans, policies, goals, and procedures would be implemented through the assistance of scientists, technologists, librarians, information scientists, and administrators.

2. Establish a pilot system which would include a well-defined area of science. It has been recommended that the literature of physics and biology is more defined than the medical or engineering disciplines and would be a better starting point. This view is accepted; also there is a need to start somewhere. Precaution must be taken to permit the phase-in of other disciplines at early stages and to prevent rigidity and overemphasis of any one science. The pilot program would create pools of information at specified locations and initiate the necessary communications links between centers. It would build onto existing centers to make use of experienced personnel. A major early aim would be to prevent duplication of abstracting and indexing efforts among many centers. The journal literature would be the first to be centralized to be followed as soon as possible by all other forms of scientific communication. The organizational concept, then, is to centralize authority for plans and policy, but to keep the actual operation of

existing centers decentralized. Standards would be made at the top and strictly enforced.

3. Make information available to the user through such aggressive means as, automatic distribution of new information to registered users, expedited service, retrospective searches, identification of other scientists who are working on a particular area of research through an automatic system. Aggressiveness would extend to proven sales techniques in order to get the customer (user) interested in the product (information). Feedback of user reaction, wishes and desires would be encouraged and then seriously considered.

4. Continue working toward national and international systems especially in such areas as linguistics, automatic translation, mechanization, and information science.

In theory such a plan, although simply stated, is neither simple nor unobtainable. It is only a matter of time, the writer believes, before the questions which have been posed in this paper are answered. European countries have had a head start on the centralization of their scientific information because: (1) they could not afford the needless waste which this country endures; and (2) they view centralization as a reasonable blessing and not as a dangerous intrusion. Although it cannot be proven that other countries make better use of their own--and our--information, enough evidence is available to make us wonder.

The burden of research and development, in space, in defense weapons, in oceanography, in medicine, and in all science is reaching a critical point. If some method of curbing this

growth is not found, this country may start to lose its supremacy in more than a few areas. It is easy to dismiss the European gains in science communications as being consistent with their more centralized political systems. However, lower death rates in Scandanavia and spectacular Russian exploits in space are not isolated examples. It is realized that centralized science communication is no universal panacea for all our waste and inefficiency and that science alone cannot cure other pressing social and moral issues. However, since our haphazard methods have not worked, perhaps it is time to change and to better organize the Nation's information efforts. If the system fails there will still be many beneficial side-effects from a critical examination of our whole information structure.

There is a final argument in favor of continuing the existing system which should be discarded. It is often said that our scientific information system is too vast and would cost too much to ever be centralized. A reply to such a conclusion would be that since we have such a problem now we had better not wait much longer; for delay will make the ultimate system even more difficult to organize.

The major problem at hand was clearly stated over four hundred and fifty years ago by Niccolo Machiavelli, in The Prince:

> It must be considered that there is nothing more difficult to carry out, nor more doubtful of success, nor more dangerous to handle, than to initiate a new order of things. For the reformer has enemies in all those who profit by the old order, and only lukewarm defenders in all those who would profit by the new order . . .[1]

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[1]The Prince and The Discourses, trans. Luigi Ricci with revision by E.R.P. Vincent (New York: The Modern Library, 1950), p. 21.

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